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A New Method for Designing Amplifiers with Ability of Controlling Band Width and Gain Stability

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Abstract: The purpose of this paper is to control band width of amplifier with the least amplification gain change in regard to determining band width by amplifier components which its most important is a capacitor capacity between input and output. In this writing, chang of capitor capacity between input and output in transistor to control band width is considered. Also, theoretical calculation and the results of computer simulation have studied.

Key words: Band width control · Amplifier · High cut off frequency · Varactor diod

INTRODUCTION

Today, because of communication systems expansion and the growing need of users the necessity of frequency valuable band width control due to non-interference is one of main characteristics of communication systems. Firstl y, band width of a common simple emitter amplifier is evaluated and then the proposed new method is presented. band width (B.W) of high (fh) and low (fl) frequencies amplifier is studied by analysis Ac in two steps and finally, B.W is obtained from deducting these two values.

As Figure 1 indicates, the effect of any capacitor in system on frequency response will be studied. Accordingly, by analysis of low cut off frequency, to obtain frequency resulted from any capacitor, all capacitors in circuit except for capacitor being analyzed, is shorten and also all DC resources become effectless then reflected equivalent resistor in view of capacitor under study (using common transistor models for analysis of low cut off frequency such as Π and model hybrid) will be obtain according to capacitor capacity of produced frequency and from Eq. (1):

$$f = \frac{1}{2\pi RC} \quad (1)$$

The following relations have obtained after simplifying circuit on AC analysis and afterwards will be used [1].

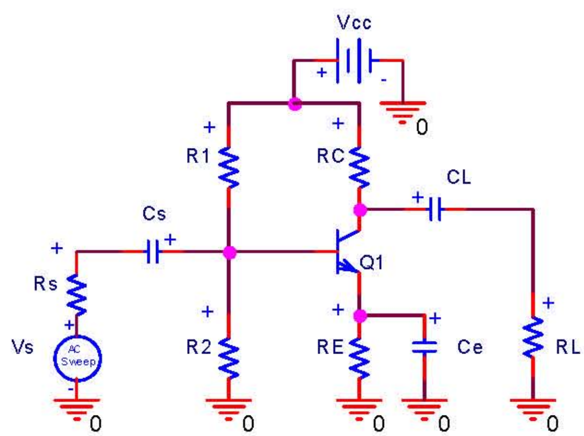

Fig. 1: Common emitter simple amplifier circuit

$$\begin{cases} R_1 \,||\, R_2 = R_B \\ R_L \,||\, R_C = R'_L \end{cases} \quad (2)$$

According to above relations, for couplage and by pass capacitors, produced frequency by any capacitor and reflected equivalent resistor in this frequency is introduced. It is obvious, from three produced frequencies, the biggest is low cut off frequency [2].

The Proposed Technique and Method: In Eq. (1), with respect to reversed ratio of frequency and C equivalent capacitor capacity (internal capacitor of transistor in high frequencies), high cut off fvequency is obtained from equivalent capacitor capacitor capacity of high frequency model (between input and output). Generally, considering

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Table 1: Determination of effect of common emitter simple circuit different capacitors on low frecuency response

Reflected resistor of capacitor effect	Frequency related to capacitor on analysis of low frequency	Determination of effect of amplifier circuit capacitors on low frequency response
Ri (Rc1) = {RL ‖ hie ‖ RB} Rs	*f lcs= {1/2Π C1(Rs+ RL'‖ hie ‖ RB)}*	Low cut off frequency from Cs effect
Rl={[Rs ll RB ll hie]}+ RL'	*flcl={1/2πC2{[Rs ll RB ll hie]}+ RL'}*	Low cut off frequency from CL effect
Re={[Rs ‖ RB ‖ hie ‖ RL' / 1+hfe] ‖ RE}	*f lce= 1 /2πC3{[Rs‖RB ‖ hie ‖ RL' /1+hfe] ‖ RE}*	Low cut off frequency from Ce effect

Miller-effect on high frequency model (Π hybrid model) Cu capacitor is, in effect, same Cbc capacitor and is converted to two capacitors between input and output. So, it can be found that the most effective capacitor (in amplifier high cut off frequency) is Cbc capacitor. Now if a very small capacitor capacity become parallel with this capacitor, high cut off frequency can be displaced and controlled in a large extent. This process is done by varactor diod located between input and output of transistor.of course, varactor diod with different capacities are used for all kind of amplifiers.capacitor capacity of these diods is controllable by voltage of both heads of diod. Then, effect of increasing this capacitor diod on amplifier will be studied in terms of theoretical arguments [3].

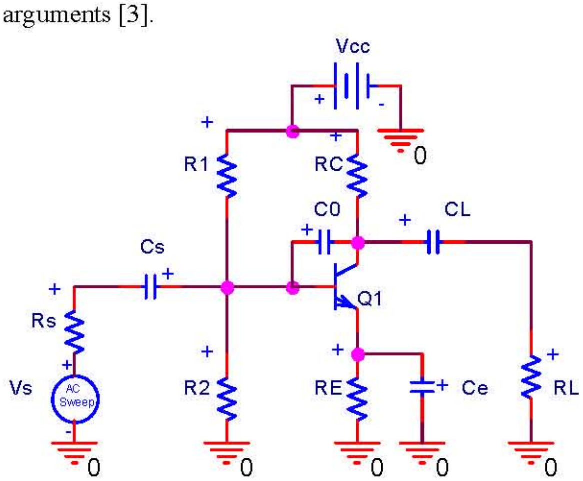

Fig. 2: Common emitter amplifier by adding varactor diod (C0 capacitor)

On analysis of low cut off frequency, in introductory section, effect of coulage and by pass capacitors was evaluated and all done necessary analyzes in that section are valid for the proposed new circuit, too. But, because of adding varactor diod to circuit, a new capacitor capacity is produced and its effect on low frequency response is analyzed as follows [2, 4]:

$$R\ CO = \{[Rs\ ll\ RB\ ll\ hie]\} + RL'$$

$$f\ lC0 = \{1 / 2\,\Pi\ C0\{[Rs\ ll\ RB\ ll\ hie]\} + RL'\} \quad (3)$$

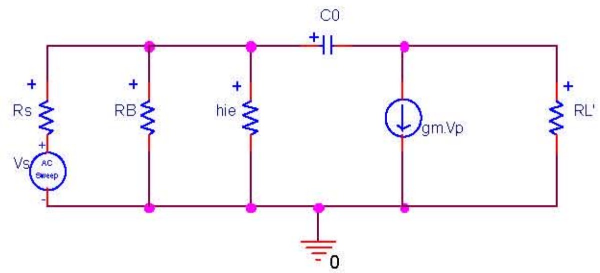

Fig. 3: Conversion of hybrid model to amplifier AC model for determining effect C0 on low frequency response

Analysis of Proposed Model High Frequency

Π Hybrid Model: Small signal ac equivalent circuit of high frequency transistor that is an approximation of Jiacoloto model is as follow:

Cu capacitor is converted to two capacitors in input and output of circuit using Miller-effect. Then, circuit is analyzed in high frequencies and Π hybrid model is replaced by it [5].

Next, CT equivalent capacitor is divided between input and out put using Miller-effect. $(CT = C0 + Cu)$

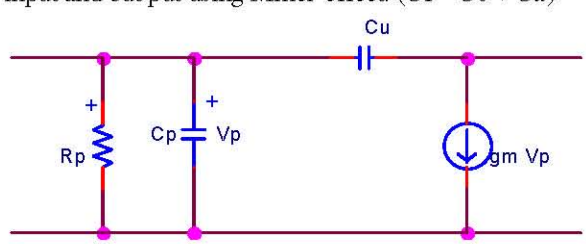

Fig. 4: Π hybrid approximate model

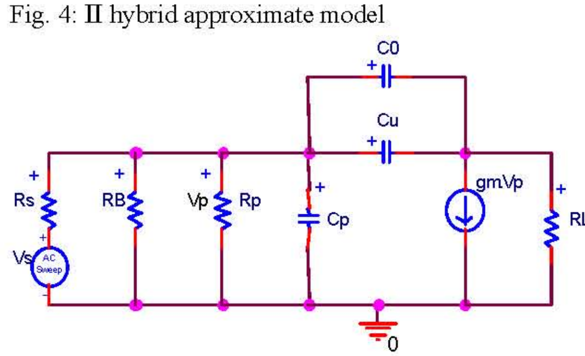

Fig. 5: Conversion of Π hybrid model to amplifier AC model

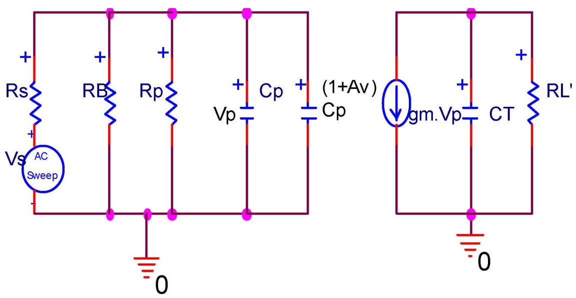

Fig. 6: Division of CT capacitor using Miller-effect

Miller-effect:

$$Cmi = \{(1+Av)CT\}+Cn\} \quad (4)$$

Produced frequency in input:

$$f\,h1 = \{1/2nCMiRi) \rightarrow Ri=\{Rs \parallel RB \parallel rn\} \quad (5)$$

And also produced frequency in out put is:

$$CMO=CT \text{ and } RO= RL' \rightarrow f\,h2 = \{1/(2n.CMO.RO)\} \quad (6)$$

Control and Determination of Amplifier Band Width: Band width of a common emitter without varactor diod is as follow:

$$B.W = fh - fl$$

$$B.W= \{1/\ 2n\ (Cn+CMi)Ri\}\text{-}\{1/2nC3\ \{[(Rs \text{ ll } R2 \text{ ll } R1 \text{ ll}) +hie] / (1+hfe)] \text{ ll } RE\}\} \quad (7)$$

Now, like above, new band width is evaluated as new band parameter considering varactor diod and it is clear that on high frequency analysis, the smallet frequency is high ct off frequency. In regard to very low value of $C0$ capacitor, cut off frequencies can be recognized in any state and band width can be computed [6, 7]:

$$B.W = fh - fl$$

$$B.W = \{1/(2n.\ (1+Av)CT\}+Cn\}.\ \{Rs \parallel RB \parallel rn\}\ -\ \{1\ /2nC3\ \{[(Rs \parallel RB \parallel hie \parallel RL']\ /\ (1+hfe)\ ] \parallel RE\} \quad (8)$$

It is observed that band width along with new added capacitor is controllable in regard to $C0$ capacitor. Meanwhile, it is reminded that addition of this capacitor has no effect on gain and also on system stability and with respect to stability, circuit conserves fully previous conditions. (In related figures, gain is constant).

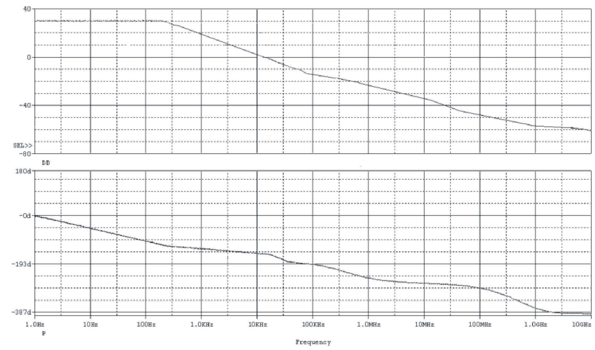

Fig. 7: Bode diagram for worst state at C0=1PF

Table and Simulation: Next, the results of computer simulation by Pspice 9.2 are shown:

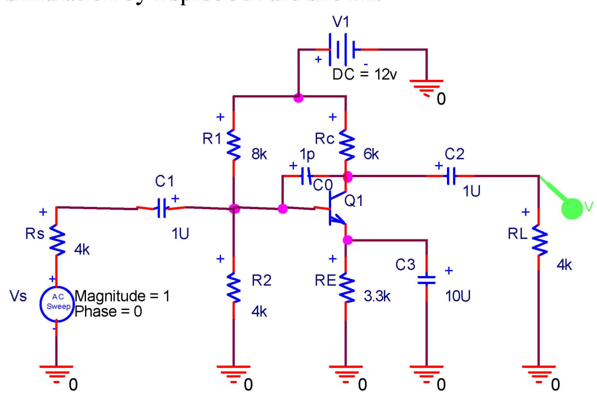

Fig. 8: Amplifier with numberical values]

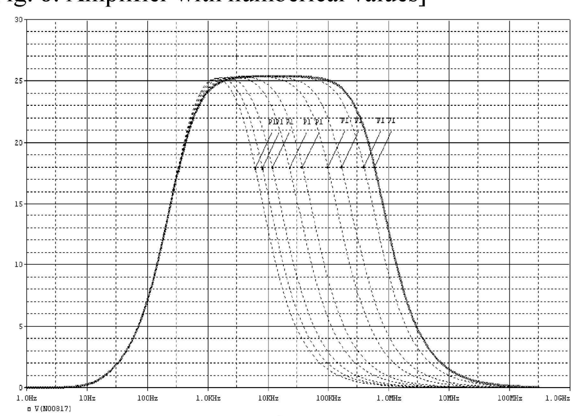

Fig. 9: Computer simulation-in this simulation, cut off frequencies are as follow for any state respectivity according to diagram for right to left:

fh(C0=0*pf*) = 574.67*KHz withot* C0 *capacitor*
fh(C0=1*pf*) = 384.83*KHz*
fh(C0=5*pf*) = 165.91*KHz*
fh(C0=10*pf*) = 97.084*KHz*
fh(C0=30*pf*) = 36.689*KHz*

$fh(C0=50pf) = 22.728KHz$
$fh(C0=100pf) = 11.769KHz$
$fh(C0=150) = 8.0161KHz$
$fh(C0=200pf) = 6.1185KHz$

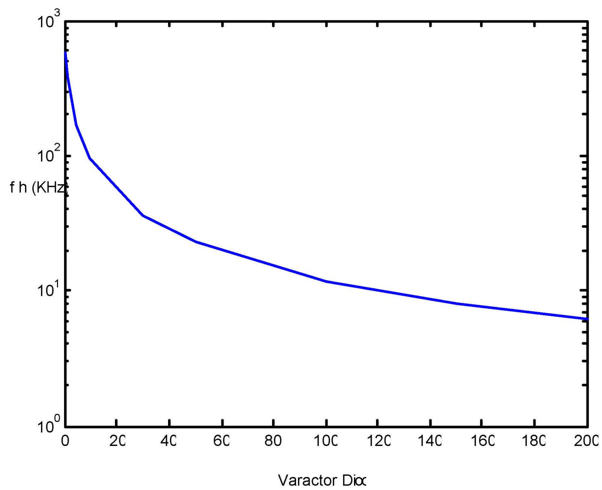

Fig. 10 and Table 2: High cut off frequency changes and consequently B.W relative to change of varactor diod capacitor capacity (since low cut off frequency is constant)

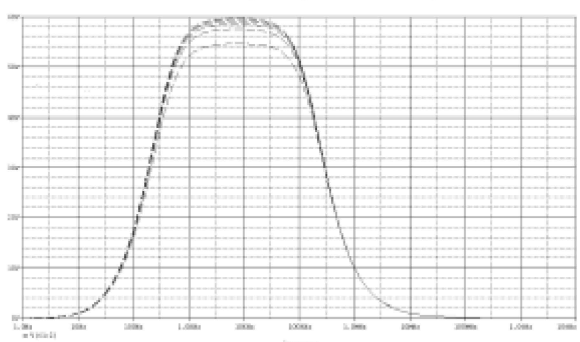

Fig. 11: The effect of resistive load (RL=10k to 330kand C0=1PF)

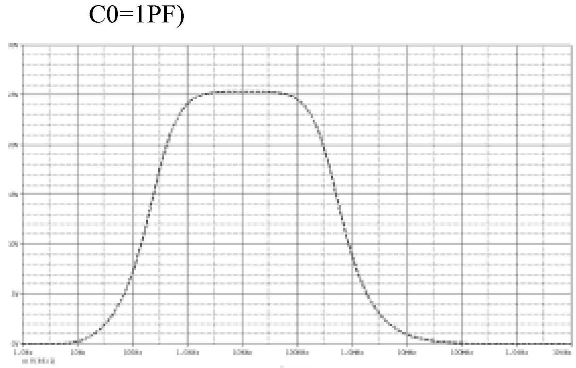

Fig. 12: The effect of resistive-Inductive load (L=1mH to 1pH and RL=4k and C0=1PF)

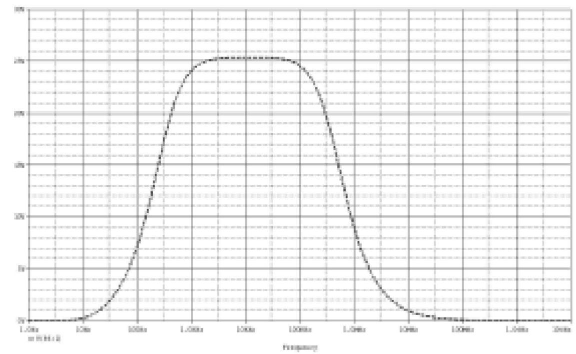

Fig. 13: The effect of resistive-Capacitive load (CL=100uf to 1pf and RL=4k and C0=1PF)

CONCLUSION

According to offered material and corresponding of practical and theoretical findings,we can conclude that band width is controllable in wide range of amplifiers and other electronic systems using suggested model and technique in this writing.

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