Modeling and Performance Improvement of Multistage Fractional Order BJT Amplifier
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Abstract:
The purpose of this work is to compare the performance of a multistage fractional order RC based transistor amplifier with its linear partner. Here, the capacitor of the fractional order is made with Domino logic in the realization of the measured flow rate at the simulation level and the test angle is compared with the actual order. The cooked capacitor is made by calculating the specifications and determining the resistance values of the required capacities of the breaking capacitor. The fractional order capacitor built into MATLAB Simulink is used in a multistage BJT based RC integrated amplifier and frequency domain analysis is obtained and compared with the fractional capacitor commands (α = 0.4, 0.6, 0.8 and 1.0). This work is being carried out in time domain analysis of the BJT amplifier which gratifies the generation of step signal. The step signal provided to the amplifier circuit gives the response providing the settling time, peak time etc.

Keywords: Multistage amplifier, Fractional order circuits, Settling time, Domino logic, MATLAB/Simulink.

I. INTRODUCTION
In practical applications, the output of a single state amplifier is usually insufficient, even though it is electric or boosting power [1]. Therefore, they are replaced by Multi-phase transistor amplifiers. For multi-phase amplifiers, the first-phase effect is coupled to the next-phase input using the coupling tool. These integrated devices can usually be a capacitor or a transformer. This process of joining two stages of the amplifier using a coupling device can be called Cascading. This is a widely used coupling method, developed using simple resistor-capacitor combinations. A capacitor that lets AC and blocks DC is the coupling factor used here. The coupling capacitor exceeds the AC from one phase output to its next phase input[2]. While blocking DC elements from DC bias voltages to perform the next phase. Let's get into details of how to put together future chapters. The two-stage amplifier circuit has two transistors, connected in CE configuration and a common power supply V_CC is used. The potential divider network R1 and R2 and the resistor R_e constitutes the biasing and stabilization network. The emitter by-pass capacitor C_e offers a low reactance path to the signal. The resistor R_L is used as a load impedance[3]. The input capacitor C_in present at the initial stage of the amplifier couples AC signal to the base of the transistor. The capacitor C_Ce is the coupling capacitor that connects two stages and prevents DC interference between the stages and controls the shift of operating point. The figure below shows the circuit diagram of RC coupled amplifier[4]. Fractional calculus can be defined as the compilation of classical mathematics in the orders of integration and division not the most important. Or the concepts of non-absolute labor are not new, in the first place. The meeting addressed in this article took place in 1974, in New Haven, Connecticut, USA. Even in such an event, fractional calculus was a matter of course a special interest of a few mathematicians and a theoretical theory[5]. However, conditions have changed dramatically since then. On the other hand, in the last 3 years the general interest in such a tool has gained momentum growing up, and right now we can find more conferences, audios, workshops, or special occasions, as well as special papers and issues in recognized magazines, devoted to the features of ideas and the application of the calculation system. On the other hand, as can be seen in such conferences and in newspapers, a catalyst for this growing interest in engineering applications, especially control engineering[6].

II. OPERATION OF RC COUPLEDAMPLIFIER
In amplifiers, cascading is also done to achieve correct input and output impedance for specific applications depending upon the type of amplifier used in individual stages, multistage amplifiers can be classified into several types[7].

1. A multistage amplifier using two or more single stage common emitter emitter amplifier is called as cascaded amplifier[8].

2. A multistage amplifier with common emitter as the first stage and common base as second stage is called cascode amplifier[9].

Such cascade and cascode connection are also possible with FET amplifiers. When the amplifiers are cascaded, it is necessary to use a coupling network between output of one amplifier and input of following amplifier[10].This type of coupling is called as inter stage coupling. When an AC input signal is applied to the base of first transistor, it gets amplified and appears at the collector load R_C which is then passed through the coupling capacitor C_C to the next stage. This becomes the input of the next stage; whose amplified output again appears across its collector load[11]. Thus, the signal is amplified in stage by stage action. The important point that has to be noted here is that the total gain is less than the product of the gains of individual stages[12]. This is because when a second stage is made to follow the first stage, the effective load resistance of the first stage is reduced due to the shunting effect of the input resistance of the second stage. Hence, in a multistage amplifier, only the gain of the last stage remains unchanged. As we consider a two-stage amplifier here, the output phase is same as input. Because the phase reversal is done two times by the two stage CE configured

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amplifier circuit[13]. The circuit diagram in figure 1 represents the two stage BJT amplifiers, the above amplifier is being used in this work for the generation of step response in time domain analysis.

![Circuit diagram of BJT based multistage amplifier.](image1)

Figure 1. Circuit diagram of BJT based multistage amplifier.

The circuit is then implemented in MATLAB/Simulink R2011a in integer domain as shown in figure 2. Two npn - transistors are being used for situating the two-stage amplifier. The step response is first given to Simulink to ps converter then it is used to controlled voltage source which actuates the circuit in its positive and negative terminals[14]. The step response of the integer order two stage BJT based amplifier is shown in figure 3. The plot shows that without having a descriptive peak value overcoming one and a half oscillations the step response settles at 140 m sec.

![MATLAB modeling of integer order multistage amplifier.](image2)

Figure 2. MATLAB modeling of integer order multistage amplifier.

![Step response of integer order multistage BJT amplifier](image3)

Figure 3. Step response of integer order multistage BJT amplifier.

III. FRACTIONAL ORDER MULTISTAGE AMPLIFIER

The conceptualization of the phase ordering system has opened the doors to many applications with unique functionality, which were not available for standard circuit components such as inductors and capacitors. In contrast to traditional objects, the invention is a function of the value of the parameter (C or L) and the order α, which brings about greater freedom and a variety of design and application functions [15]. The concept has already received its widespread use of electromagnetics, mechanics, signal processing, bioengineering, agriculture and control. We have found many exciting services for fractional theory in the RF and microwave domain. Preliminary investigations predict paradigm shifts in the basic concepts and concepts used for these projects. Theories of fractional ordering became first known in 1941 by the Cole brothers for the display of technical symbols, where α is the fractional order varying from 0.4 to 1.0 where R is the unit of Ω and the veneer of the second unit and z is the fractional number. In the literature, many researchers favor items that are different from the FC and FI and their performance as shown below. An available element with a phase angle between 0 ° to 90 ° and independent of frequency is called a projected capacitor. Fractional capacitor interference is given in the equations. There are different methods to solve fractional differential equations analytically. One of the most common and widely used methods is the Laplace transform. In the following, by an example, this method is illustrated (for other methods see reference [1]). Before proceeding, it is worth noting that in general, the number of initial conditions that are required for a given ordinary differential equation will depend upon the order of the differential equation. However, in the fractional differential equation, number of initial condition equals to the...
integer lower bound of order value (\(\alpha\)) [16-18]. Consider the following differential equation

\[ \xi D^\alpha x(t) + kx(t) = f \]  

(1)

Which \(x(t)\) is displacement, \(k\), and \(\xi\) are constants, as well as the fractional derivative is also Caputo and \(0 < \alpha < 1\)--In what follows, it has been shown that this differential equation model is the dynamics of a purely elastic spring and a viscoelastic element connecting in parallel with a body of mass \(m\), which a force \(f\) is applied on a body[19-21]. In order to solve, the first step is to take the Laplace transform of both sides of the original differential equation, we have,

\[ X(s) = \frac{f}{\xi (s^{\alpha} + \frac{k}{\xi s})} \]  

(2)

where \(\alpha\) and \(s\) are fractional order and Laplace domain variable respectively. Also, it is supposed that \(x(0) = 0\). To find the solution, all we need to do is to take the inverse transform,

\[ x(t) = \frac{f}{\xi} t^{\alpha - 1} E_{\alpha,\alpha} \left( -\frac{k}{\xi} t^\alpha \right) \]  

(3)

Which \(E_{\alpha,\alpha}(t)\) is Mittag-Leffler function . In the last example, if the spring is ignored, the Eq. 1 will be reduced to,

\[ f = \xi D^\alpha x(t) \]  

(4)

Then as above, by a) taking the Laplace transforms of both sides of the equation, b) simplifying algebraically the result to solve the obtained equation in terms of \(s\), and c) finally finding the inverse transform, we have

\[ x(t) = kt^\alpha \]  

(5)

Where \(k = \frac{f}{\xi T(1+\alpha)}\)  

(6)
From the analysis seen in figure 5, it is being observed that the fractional order amplifiers serve as a better settling device as compared to its integer order counterpart. In this observation the orders of α varied from 0.2 to 1.0 and we observed the peak overshoot of the all cases remained constant but the settling time is the fastest as α=0.8.

IV. CONCLUSIONS

Modeling the proposed amplifier, it is concluded that the time domain analysis providing the step response gives a hussy and uneven oscillations in integer order BJT RC coupled amplifier. In case of fractional order amplifier circuit, the settling times reduces a lot in increase of the fraction order α of the fractional capacitor from 0.2. It is then observed that at α=0.8 the best step response ever is being obtained. Thereafter, the analysis imprints that fractional order BJT based amplifier is proved to be providing better responses with greater stability as compared to conventional integer order BJT based amplifier.

V. REFERENCES


