OTA Based 2nd Order Butterworth Filter For Mobile Communication using CMOS Technology

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Abstract. Communication is the process of transmitting knowledge from one person to another. Receivers have a vital role to play in communication. The main role of receivers is to replicate the message signal in electrical form from the wrapped transmitted signal. Receivers accept signals, such as radio waves and convert them into useful form. The type of receiver that is commonly used is the Direct Conversion Receiver (DCR) that translates the signal directly to the baseband frequency. In this paper, we are concentrating on the Low Pass filter to block unwanted signals from mixer stage. A 2nd order Butterworth filter is designed by implementing a active load differential amplifier &a active load common source amplifier, further the operational trans conductance is designed by using the above mentioned two circuits. The designed OTA is implemented with two capacitors at the input stage and at the output stage which makes it a Butterworth Filter.

Keywords : Butterworth Filter, Lowpass Filter, Operational Transconductance Amplifier, OTA, CMOS Technology. Gm-C filter

1 Introduction

The cellular or telephone network is a contact network where the last connection is wireless. The network is spread over land-based areas known as "cells", each supported by at least one fixed-location transceiver, though more commonly, three cell sites or a base transceiver station. [1,2] Such base stations provide a cell with network coverage and can be used for the transmitting of speech, data and other forms of information. [3] A cell usually uses a separate range of frequencies from adjacent cells to prevent intrusion and to have assured service efficiency within each cell. The block diagram of communication system is shown as shown in Figure1.

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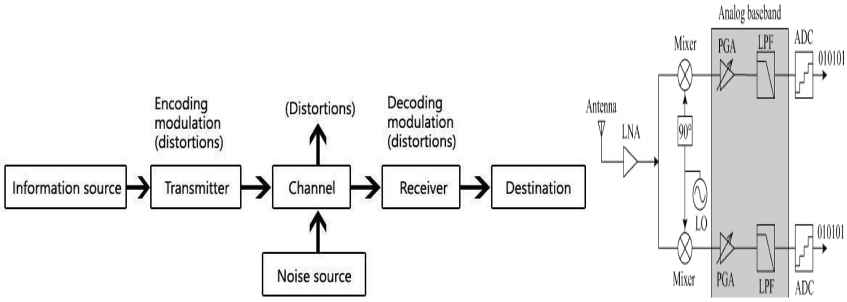

Fig 1: (Left) Block diagram of communication system. (Right) Block diagram of direct conversion receiver

The process is enabled with a DCR [4] [5] The ideal filter response cannot be exactly obtained in the practical filter because an ideal low pass filter has an infinitesimally small transition band. In practice we see real low pass interpolators have a small transition band centred around centre frequency [6[[7].

2 Proposed Method

The Butterworth filter is a type of filter built to process signals to have as flattest possible frequency response in the pass band. This is also called as a filter of maximum flat curve.

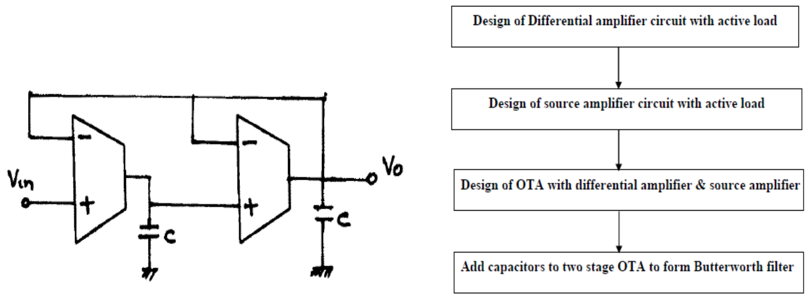

Fig 2: (Left) Block diagram of 2nd order Butterworth filter, (Right) Flow chart for designing 2ndorder Butterworth filter.

The most important part of this filter is Operational trans conductance amplifier. At the input stage of the OTA a Resistor-Capacitor is connected to make it a 1st order Butterworth filter. Cascading another stage of same RC connection along with OTA gives the 2nd order Butterworth filter.

Step 1: The design of Differential amplifier circuit with active load is obtained. We are designing this because, by using active load, differential- mode gain can be increased and therefore eliminates distortion present in two input signals.

Step 2: Design of Source amplifier figure 6 circuits with active load is implemented since it has high input impedance and low noise performance make them suitable for use in amplifier circuits.
Step 3: Now the output of differential amplifier as well as common source amplifier is used in implementing OTA Figure 8.
Step 4: In order to form 2nd order Butterworth filter Gm-C filter circuit is connected to the OTA figure 9.
Step 5: Analyze the phase and Magnitude Plot of the Gm-C.

Implementation of Differential amplifier

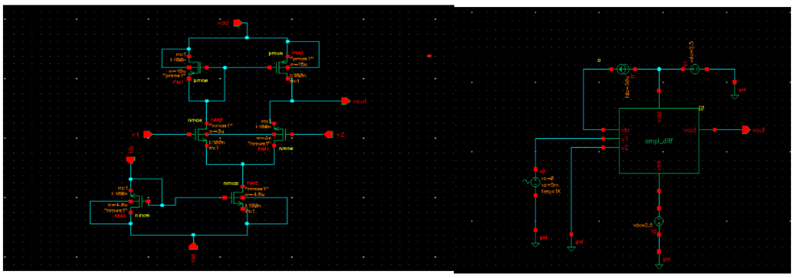

Fig 3: Schematic representation of differential amplifier

The input resistance of a common source amplifier with active load is given by

$$R_{in} = \infty$$

The input voltage is given by

$$V_1 = V_{in}$$

The output voltage is given by

$$V_{out} = -G_{m2}V_{in}(r_{o1} || r_{o2})$$

The voltage gain of common source amplifier with active load is given by

$$A_V = -\frac{V_{out}}{V_{in}} G_{m2}(r_{o1} || r_{o2})$$

Implementation 2nd order Butterworth filter

Gm-C method has been chosen for implementation of the filter. The explanation behind the use of Gm-C is that the transconductance value differ in the fast tuning capacity. The Gm-C filter still has a low noise but is reduced to the system to handle large signals. The transconductance depends on the various design parameters of the CMOS transistor has to be carefully selected in order to gain the necessary value in terms of linearity[8][9]. OTA based Gm-C filter is faster than Op-amp-C filters and MOSFET-C. Gm-C filters, also called as Transconductance-C filters are commonly used in applications of high frequencies. A Gm-C filters building block is an integra-

tor and a capacitor. A transducer is a voltage-controlled source of current, by which can be tuned by varying DC bias
The transfer function of 2nd order Butterworth low pass filter is given below

$$H(S) = \frac{Vout}{Vin} = \frac{\frac{gm2\ gm3\ gm4}{gm4\ C1C2}}{S^2 + \frac{gm2}{C1}S + \frac{gm3gm4}{C1C2}}$$

The transfer function of 2nd order LPF is given by

$$H(S) = \frac{\omega_0^2}{S^2 + \frac{gm2}{C1}S + \omega_0^2} \quad \omega_o^2 = \frac{gm3gm4}{C1C2} \quad \frac{\omega o}{Q} = \frac{gm2}{C1}$$

gm1=gm3=gm4=gm and C1=C2=C

$$\omega_o = \frac{Gm}{C} \text{ and } Q = \frac{Gm}{gm2} \qquad Gm = \frac{Iout+ - Iout}{Vin+Vin^-}$$

3 Simulated Results

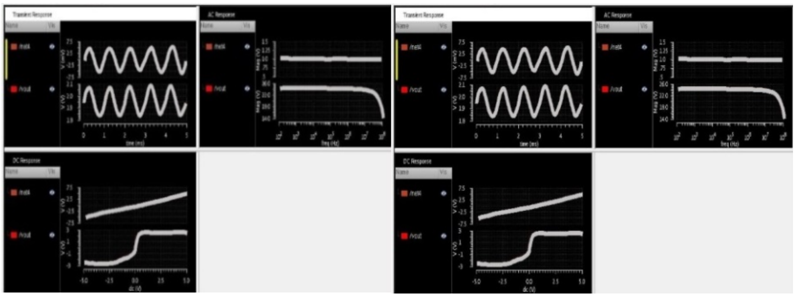

Fig 5: Transient, AC, DC response of Common Source Amplifier

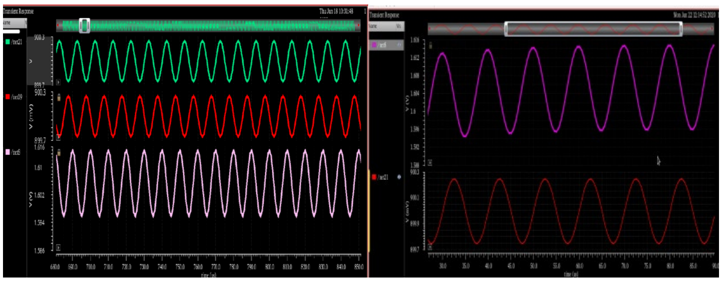

Fig 6: Transient response of Gm-C filter

4 Conclusion

Communication is the transmittal of information from person to person. When we say communication; obviously it includes two major components that is receiver and transmitter. Receivers play vital role in communication. Now we have designed a part of the receiver by using 2nd order Butterworth filter.A 2nd order Butterworth low pass filter was designed and simulated for direct conversion receiver. Parameters affection a filter's output have been explored.The method is based on cascading of common source and differential amplifier. The performance of the filters designed is analyzed using various parameters like center frequency, gain, bandwidth, Q factor, slew rate and Roll off factor.

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