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5. Realization of Active Band Pass Filter for Low Radio Frequency Identification (RFID) Model

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ABSTRACT

An active 4th order band-pass filter for RFID reader is fabricated and simulated. For this purpose, an active bandpass filter is required for the front-end system because all signals outside the 10-20 kHz time-varying signal backscattered by the tag need to be rejected. The filter has been designed from some given specifications, one of which is, that the filter needs to have a Butterworth response. The values for the passive components are calculated, and the circuits are then simulated using MATLAB commercial software.

KEYWORDS

Band-pass filter, MATLAB, & RFID (Radio Frequency Identification)

Introduction

In the low frequency RFID system, active filters are used because of the subsequent reasons:

- active filter will generate a gain larger than one.
- higher order filters will simply be cascaded since every Op-amp is second order
- filters are smaller in size as long as no inductors are used, that makes it terribly helpful as integrated circuits.

At some purpose of the direction of take a glance at, an active band-pass filter is designed and simulated. An active band-pass filter is applied for the RFID device to reject all indicators outside the symptoms and to increase the low antenna signal. The identification alerts from the tag are 12.5 kHZ and 15.65 kHZ and signal strength may well be terribly low [1-3]. Butterworth type has been accustomed get a maximally-flat reaction. In the next section of this paper, the band-pass filter design has been determined with its specifications. And then implementation of 4th order Butterworth band-pass filter design has been carried out in order to meet the design specifications.

Design Thought

The design that has been accustomed implement the fourth order band-pass filter is Sallen-Key Topology. [4-5] This was chosen owing to its simplicity compared to alternative noted architectures like multipe feedback and state variable, wherever the latter is for exactness performance.

Butterworth filter response is employed to induce the most flat gain. The Active - RC Butterworth filters have a variety of benefits once used for lower order of the filter: have glorious one-dimensionality, have low power dissipation and area unit simple to style and analyze. The filter response is insensitive to parasitic, and its massive Dynamic vary

A circuit diagram for second order Sallen-Key band-pass filter is shown in Fig.1.

Table.1 illustrates the specifications for the specified bandpass filter.

By mistreatment the subsequent filter parameters, the specified filter has been designed and simulated with circuit maker and MATLAB.

Design Implementation

According to transfer function for the fourth order band-pass filter, it can be written as follow:

$$A(s) = \frac{\frac{A_{mi}}{Q_i}\alpha.s}{\left[1+\frac{\alpha.s}{Q_i}+(\alpha.s)^2\right]}\cdot\frac{\frac{A_{mi}}{Q_i}\alpha.s}{\left[1+\frac{1}{Q_i}\left(\frac{s}{\alpha}\right)+\left(\frac{s}{\alpha}\right)^2\right]}$$

(1)

Where

- Ami is the gain at the mid frequency, f_{mi}, of each filter
- Qi is the pole quality of each filter
- α and 1/α are the factors by which the mid frequencies of the individual filters, f_{m1} and f_{m2}, are derived from the mid frequency, f_m, of the overall band-pass. Facto α needs to be decided via successive approximation, the use of the subsequent equation.

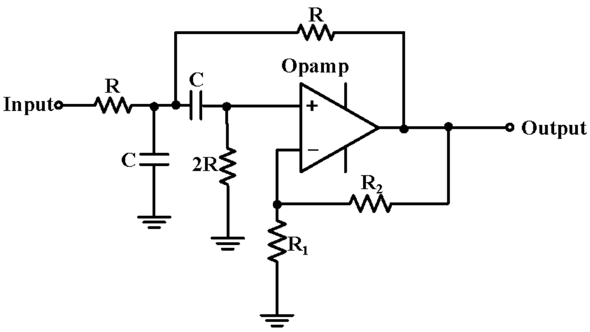

Fig. 1. Second Order Sallen-Key Filter

Table 1. Band-pass Filter Specifications

Center frequency	15 kHz	
Pass band Frequency	10 kHz	20 kHz
Pass band Ripple	0.1dB	
Stop band Attenuation	60dB	
V_{p-p}	100µV	

$$\alpha^2 + \left[\frac{\alpha \cdot \Delta\Omega \cdot a_1}{b_1\left(1+\alpha^2\right)}\right]^2 + \frac{1}{\alpha^2} - 2 - \frac{\left(\Delta\Omega\right)^2}{b_1} = 0$$

(2)

where normalized bandwidth $\Delta\Omega=1/Q_{BP}$, (Q_{BP} is the overall quality of the filter), with a1 and b1 being the second order low-pass coefficients of the desired filter type.

For Butterworth filter type,

- $a_1 = 1.4142$ and
- $b_1 = 1$

4^{th} -order Butterworth Band-Pass filter has been considered with the following parameters:

Pass band frequencies = (10-20) kHz

Mid frequency of the filter,

fm = 15 kHz

Let overall gain at mid-frequency,

A^m = 2

Bandwidth, BW = $f_H – f_L$ = 10 kHz

$$QBP = \frac{f_m}{BW} = 1.5$$

By using equation (2),

α = 1.2711 is obtained.

After α has been determined, all portions of the partial filters can be calculated as follows:

The mid frequency of filter 1 is:

$$f_{m1} = \frac{f_m}{\alpha} = 11.8 \text{ kHz}$$

The mid frequency of filter 2 is:

$$f_{m2} = f_m \cdot \alpha = 19.067 \text{ kHz}$$

The pole quality Q_i, is the same for both filters:

$$Q_i = Q_{BP} \cdot \frac{(1+a^2)b_1}{\alpha \cdot a_1} = 2.1827$$

The individual gain (A_{mi}) at the partial mid-frequencies, f_{m1} and f_{m2}, is the same for both filters:

$$A_{mi} = \frac{Q_i}{Q_{BP}} \cdot \sqrt{\frac{A_m}{b_1}} = 2.0579$$

By using the following equation, we can calculate required parameters of Sallen-Key achitecture

mid-frequency: $f_{mi} = \frac{1}{2\pi RC}$

inner gain: $G = 1 + \frac{R_2}{R_1}$

gain at fm: $A_{mi} = \frac{G}{3-G}$

filter quality: $Q_i = \frac{1}{3-G}$

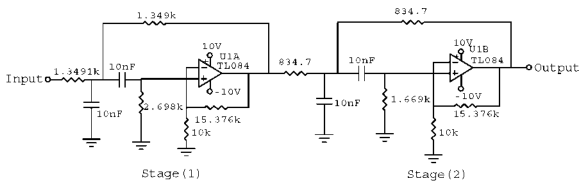

Fig. 2. 4th order Butterworth Band-pass filter

To fabricate the particular 2nd -order band-pass filters, C = 10 nF, the resistor values for both partial filters are calculated following way:

Filter 1:

	R	=	1.3491 kΩ
Let	R_1	=	10kΩ
	R_2	=	15.376 kΩ

Filter 2:

	R	=	834.7 Ω
Let	R_1	=	10kΩ

$R_2 = 15.376\ k\Omega$

The 4th order Butterworth band-pass filter is constructed from two non-identical 2nd-order sections shown in Fig.2.

The 4th order butterworth band-bypass filter out is constructed from two non-identical 2nd-order sections proven in Fig.2.

The transfer function of that circuit is

$$H(s) = \frac{0.8889s^2}{s^4 + 0.9427s^3 + 3.4413s^2 + 0.9428s}$$

By using the transfer function, the frequency response of the filter can be plotted using MATLAB to verify the design.

Simulation Results:

The results of circuit maker simulation for the fourth order Active-RC Butterworth band-pass filter are shown in Fig.3(a,b). 4th order Active - RC Butterworth filter design has passband frequencies 10 kHz and 20 kHz, passband gain of about 49 dBV and roll-off rates of -40dB/dec and 40dB/dec. [6-7]

Also, Fig.4(a,b) illustrates the frequency response of the filter using MATLAB simulation method. It can be seen that the simulated response looks good and also looks familiar with the simulated response in MATLAB, and thereby decided to be implemented in the real world.

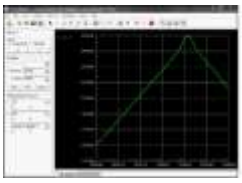

Fig. 3a

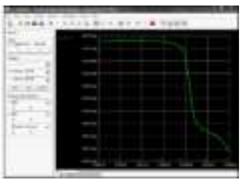

Fig. 3b

Fig.3(a,b). Simulated filter responses in circuit maker of 4th order Butterworth Band-pass filter; fig-3a shows the filter magnitude response in dB and the fig-3b shows the phase function in degrees.

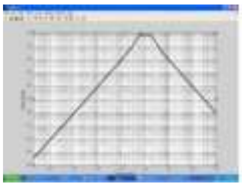

Fig. 4a

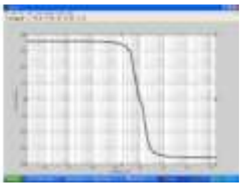

Fig. 4b

Fig.4.(a, b) Simulated filter responses of 4th order Butterworth Band-pass filter using MATLAB; fig 4a shows the filter magnitude response in dB and the fig. 4b shows the phase function in degrees.

Conclusion

Band-pass filter design and simulation for RFID system is given during this paper. Because the simulated results satisfy the system needs, these circuit structures area unit appropriate for RFID application. If more-accurate frequency response is needed, additional stages ought to be used.

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