Sonar's Filter

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Abstract - *Sonar's filter is specifically design for a condition in which we have have a input signal defined as (Vi = A sin ωt + B cos ωt) where ω is angular frequency as (2πf) and we want output as A sin ωt or B cos ωt . Sonar's filter make this possible using single passive component resistor and capacitor,By varying their configuration we can have A sin ωt or B cos ωt as output signal as presented in this paper along with circuit designing method. Circuit which produce output as (Asinωt) is called as sonar's lowpass filter and Circuit which produce output as (B cosωt) is called as sonar's high pass filter.*

Key Words: RC Highpass filter and RC Low pass filter , cutoff frequency of RC filter , Laplace transform , Transfer function of electrical circuit , Opreational Amplifier and it Application.

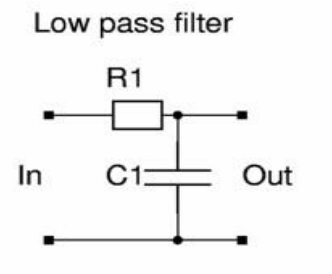
1. INTRODUCTION

In electronics we come through many signal which can be simple mathematically or complex and by signal processing method we derive required signal from given signal . Sonar's filter is a electronic circuit made using single resistor and capacitor and are capable to seperate as A sin ωt or B cos ωt when input is Vi = A sin ωt + B cos ωt . Circuit which produce output (Asinωt) is called as sonar's lowpass filter because it reassemble it circuit similar to RC lowpass filter and Circuit which produce output (B cosωt) is called as sonar's high pass filter because it reassemble it circuit similar to RC highpass filter This paper shows method to design Sonar's filter along with its output .

1.1 Basic Theory :

The purpose of this section is to recall some basic circuit and transfer function of highpass and low pass RC filters .

1.1.1 Low pass Filter :



Fig(1.1.1) circuit of RC lowpass filter

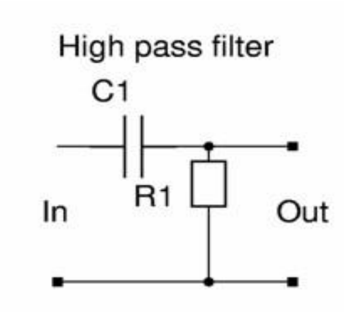
Let R1 = R and C1 = C ,than

Transfer Function :

$$Vo(s) / Vi(s) = 1 / \{ RC (s + (1/RC)) \}$$
$$= (1/RC) / (s + (1/RC)) \quad \text{\_\_\_(A)}$$

Cutoff frequency : $fc = 1 / 2\pi RC$

1.1.2 High pass Filter :



Fig(1.1.2) circuit of RC highpass Filter

Let R1 = R and C1 = C ,than

Transfer Function :

$$Vo(s) / Vi(s) = s / \{ s + (1/RC) \} \quad \text{\_\_\_(B)}$$

Cutoff frequency :

$$fc = 1 / 2\pi RC$$

Note : s = jω

2. Sonar's Filter

2.1 Designing of circuit :

To design sonar's filter we first look at how transfer function works , Every circuit has it own transfer function which is a ratio of laplace transform of output voltage to laplace transform input voltage . Since we know the input voltage as *Vi = A sin ωt + B cos ωt* , and output voltage of Sonar's lowpass filter is *A sin ωt* and *B cos ωt* is output for sonar's highpass filter , using this knowledge we will obtain transfer function of individual system and using transfer function we will define circuits , as shown

2.1.1 Sonar's lowpass filter :

This filter's input and output voltage is given mathematically as ,

input = Vi = (Asin ωt + B cos ωt) and

output = Vo = (Asin ωt)

Since we have input and output voltage so we will take laplace of both input and output voltage to obtain transfer function.

laplace of input =

Vi (s) = { (Aω / s^2 + $ω^2$) + (Bs / s^2 + $ω^2$) } and

output = Vo (s) = (Aω / s^2 + $ω^2$)

So Transfer function will be after some modification

$$Vo (s) / Vi (s) = Aω / (Aω + Bs)$$

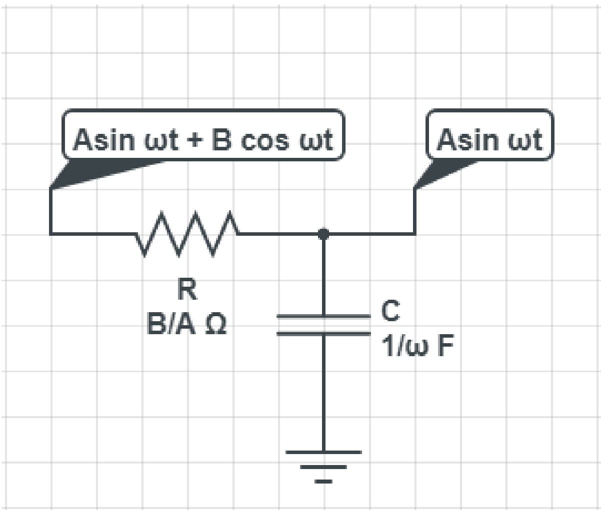
take B common from denominator , we get

Vo (s) / Vi (s) = (Aω / B) / { (Aω / B) + s } ___(C)

Now if we compare eqn(C) with eqn(A) we see that both are same if

$$1/RC = Aω/B$$

So if we replace R and C by (B/A) and (1/ω) respectively we can make RC lowpass filter to act as sonar's lowpass filter to obtain (Asinωt) as output . So actual circuit would look like ,



fig(2.1.1.1) sonar's low pass filter

Since sonar's lowpass filter is a RC low pass filter due to which it has it cutoff frequency as

$$fc = 1 / 2πRC$$

replace R and C with (B/A) and (1/ω) respectively to obtain cutoff frequency of sonar's low pass filter as

$$fc = Aω/2πB$$

since ω=2πf

$$fc = (A/B) f$$

where fc = cutoff frequency and f = signal frequency

since fc ≥ f , So (A/B) ≥ 1 as required condition to operate as sonar's lowpass filter . Because it reassemble it circuit similar to RC low pass filter it is called as sonar's low pass filter .

2.1.2 Sonar's highpass filter :

This filter's input and output voltage is given mathematically as ,

input = Vi = (Asin ωt + B cos ωt) and

output = Vo = (Bcos ωt)

Since we have input and output voltage so we will take laplace of both input and output voltage to obtain transfer function.

laplace of input =

Vi (s) = { (Aω / s^2 + $ω^2$) + (Bs / s^2 + $ω^2$) }

and output = Vo (s) = (Bs / s^2 + $ω^2$)

So Transfer function will be after some modification

$$Vo (s) / Vi (s) = Bs / (Aω + Bs)$$

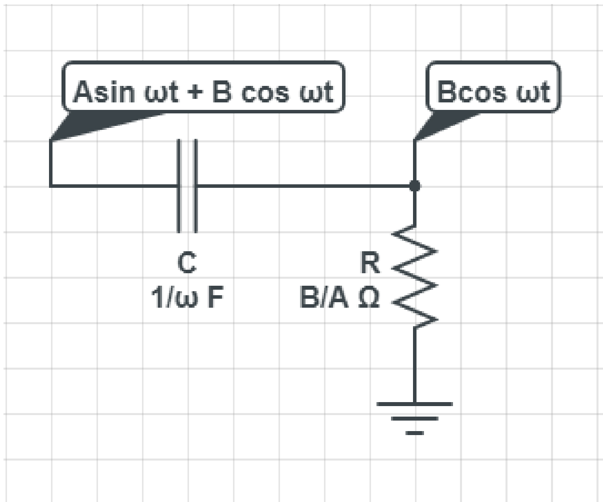
take B common from Denominator , we get

Vo (s) / Vi (s) = s / { (Aω/B) + s } ___(D)

Now if we compare eqn(D) with eqn(B) we see that both are same if

$$1/RC = Aω/B$$

So if we replace R and C by (B/A) and (1/ω) respectively we can make RC highpass filter to act as sonar's highpass filter to obtain (Bcosωt) as output . So actual circuit would look like ,



fig(2.1.2.1) sonar's highpass filter

Since sonar's highpass filter is a RC highpass filter due to which it has it cutoff frequency as

$$fc = 1 / 2\pi RC$$

replace R and C with (B/A) and (1/w) respectively to obtain cutoff frequency of sonar's high pass filter as

$$fc = A\omega/2\pi B$$

since $\omega=2\pi f$

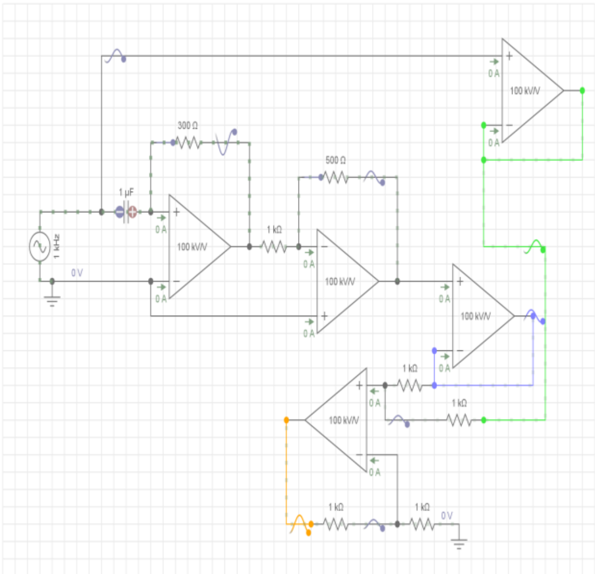
$$fc = (A/B)\ f$$

where fc = cutoff frequency and f = signal frequency

since fc ≤ f , So (A/B) ≤ 1 as required condition to operate as sonar's highpass filter . Because it reassemble it circuit similar to RC high pass filter it is called as sonar's high pass filter .

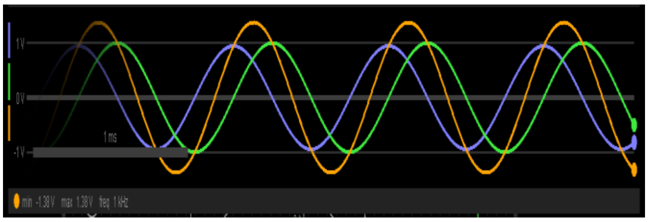
2.2 Software Simulation of sonar's filter :

2.2.1 Circuit to generate input signal :



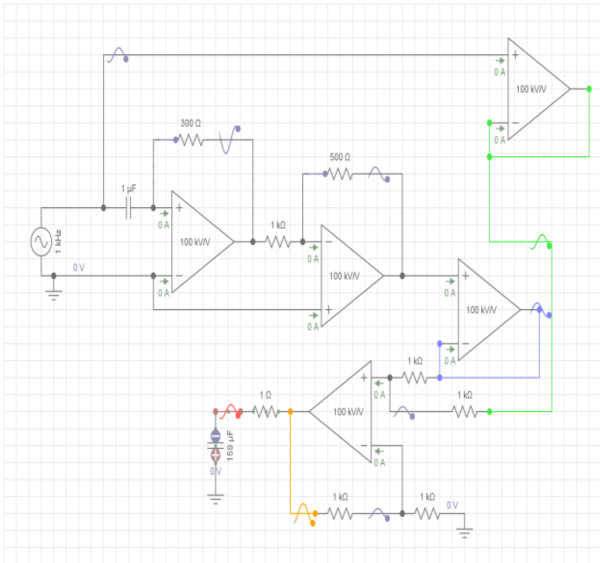
fig(2.2.1.1) Generation of input signal

figure fig(2.2.1.1) shows generation of input signal as (Vi = A sin ωt + B cos ωt), we had sine wave generator available in simulator of 1KHz frequency and we have derived cosine wave from it using active differentiator circuit since active differentiator produce inverted output so we passed inverted cosine wave to inverting operational amplifier to obtain cosine wave . Obtained sine and cosine wave are than pass through buffer to avoid any loading effect than they are added to obtain Vi = A sin ωt + B cos ωt using operational amplifier as adder . graph as shown below , Blue indicate cosine wave , Green indicate sine wave , Orange indicate Vi = A sin ωt + B cos ωt since here we have adjusted the gain of amplifiers such that both sine and cosine wave have same amplitude as 1V so that fc = f . so here we are dealing with Vi = sin ωt + cos ωt as A=B = 1V .



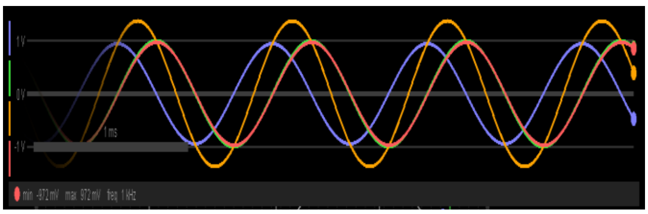
fig(2.2.1.2) Graph of circuit shown in fig(2.2.1.1)

2.2.2 Circuit for sonar's lowpass filter :



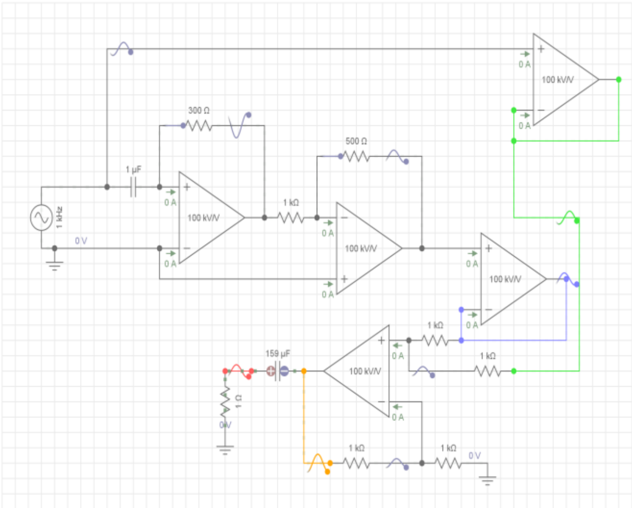
fig(2.2.2.1) Circuit to test sonar's lowpass filter

figure fig(2.2.2.1) shows that obtained Vi = sin ωt + cos ωt is passed through low pass filter or sonar's low pass filter and we obtained result is sinωt as from graph in red . Green sine wave is been overlapped with red output wave seen in graph. value of capacitor and resistor of sonar's filter is obtained from equation derived before at A=B= 1V and f = 1KHz as R = 1Ω and C = 159µf .



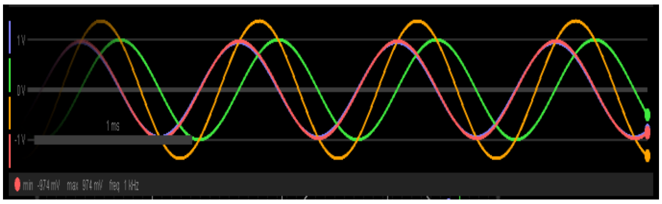
fig(2.2.2.2) Graph of circuit shown in fig(2.2.2.1)

2.2.3 Circuit for sonar's high pass filter :



fig(2.2.3.1) Circuit to test sonar's highpass filter

figure fig(2.2.3.1) shows that obtained Vi = sin ωt + cos ωt is passed through high pass filter or sonar's high pass filter and we obtained result is cosωt as from graph in red .blue cosine wave is been overlapped with red output wave seen in graph. value of capacitor and resistor of sonar's filter is obtained from equation derived before at A=B= 1V and f = 1KHz as R = 1Ω and C = 159µf .



fig(2.2.3.2) Graph of circuit shown in fig(2.2.3.1)

3. CONCLUSIONS

This paper shows that how an RC highpass or lowpass filter can be used to make sonar's highpass or lowpass filter respectively under certain condition and solve the problem using single capacitor and resistor .

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