Design and Implementation of High Speed All Pass Transformation Based Variable Digital Filters

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Abstract

- All pass transformation based variable digital filters are filters which gives variable frequencies by controlling small set of parameters when this variable digital filters has no control over cut off frequency then all pass transformation is used. All pass filters are replaced in place of delay elements of a prototype filter structure. The resultant filter provides variable frequency with control over cut off frequency and higher operating frequency, without updating filter coefficients. In this we review the first and second order all pass filter are designed using RLC circuit using cadence tool with 180nm technology these filters provides same magnitude as input it provides unity gain with a phase shift at the output.

1. INTRODUCTION (10 PT)

Variable digital filters are filters which gives variable frequencies by controlling small set of parameters when this variable digital filters has no control over cot off frequency then all pass transformation is used by replacing the delay elements of the prototype filter. In this we use first and second order all pass filters to replace the delay elements of the prototype filter, all pass filters are filters which passes all frequencies equally in gain, but changes the phase relationship among various frequencies it does this by varying its phase shift as a function of frequency. The filter is described when the input and output signals go into quadrature i.e (90˚ phase shift). The magnitude is same as the input and gain is unity. Applications are audio equalization, the design of warped adaptive filters and discrete Fourier transform based filter banks and hearing aids.

In this we use RLC circuit to design all pass first and second order filters i.e (any filter can be realized using RLC circuit).

The rest of this brief is organized as follows. Section II provides brief review of first and second-order all pass section III provides design equations of first and second order all pass filter and section IV simulation results.

2.ALL PASS TRANSFORMATION BASED VARIABLE DIGITAL FILTERS

In an all pass transformation based variable digital filter the all pass filter with an appropriate order is replaced in place of delay elements of the prototype filter the resultant filter gives variable frequencies without updating the filter coefficients.

A. First order all pass filter:

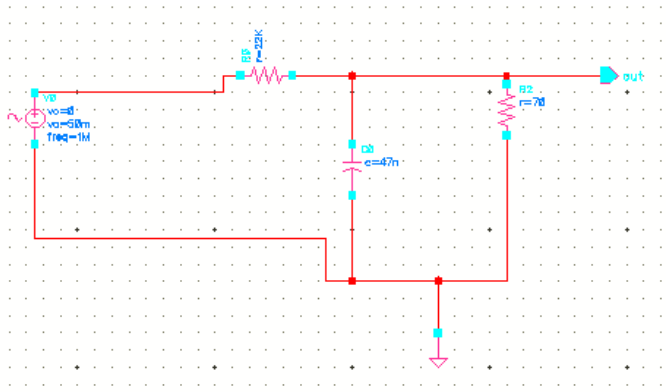

Fig 1: schematic representation of first order all pass filter

Figure (1) shows the schematic of first order all pass filter using RLC circuit, the order of filter is found by two parameters

1. Finding number of poles from transfer function.
2. Number of active elements present in the circuit.

The design of the all pass filters is designed using cadence tool with 180 nanometres technology.

The phase shift of the first order all pass filter is shown below which consists of 90˚ phase shift and magnitude of input and output is also same.

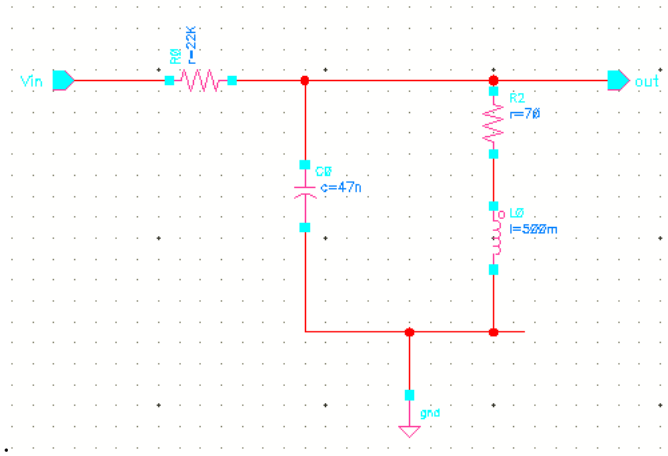

Fig 2: schematic representation of second order all pass filter

B. Second order all pass filter:

Figure (2) shows the schematic of second order all pass filter because the number of active elements present in the circuit is two so it is a second order all pass filter.

The phase is 180˚and the magnitude is same as the input.

3. DESIGN EQUATIONS

From equation (1) we can calculate the phase shift of the filter and from equations (2) and (3) we can calculate the gain and group delay of the first order all pass filter can be calculated

$$\text{phase shift}(\Phi) = \text{Tan}^{-1}\left(\frac{\text{RLC}}{2\pi\text{F}}\right) \quad \text{——————} \quad (1)$$

$$\text{Gain} = \frac{vo}{vin} = \frac{\frac{1}{RCL}}{s+\frac{1}{RCL}} \quad \text{——————————} (2)$$

$$\text{Group delay} = \frac{2RCL}{(2\pi FRLC)^2+1} \quad \text{——————————} (3)$$

From equation (4) we can calculate gain of the second order filter equation is as followed

$$\text{Gain} = \frac{vo}{vin} = \frac{s^2 - s\left(\frac{2}{R2CL}\right) + \frac{1}{R1\,R2\,C^2}}{S^2 + s\left(\frac{2}{R2CL}\right) + \frac{1}{R1\,R2\,C^2}} \quad \text{——————————} (4)$$

4.RESULTS AND ANALYSIS (10 PT)

The phase shift, magnitude and gain of the first and second order all pass filters are as follows

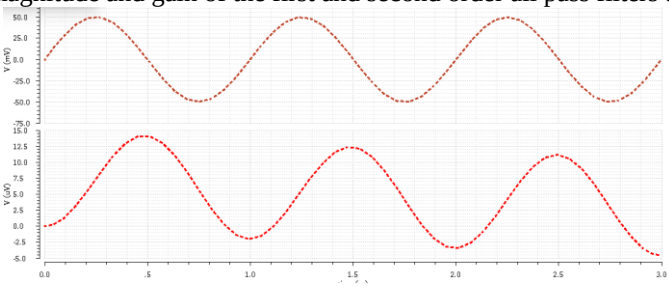

Fig 3: Transient response of first order all pass filter

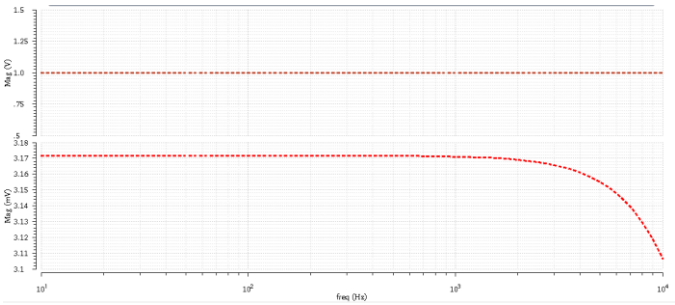

Fig 4: Gain of first order all pass filter

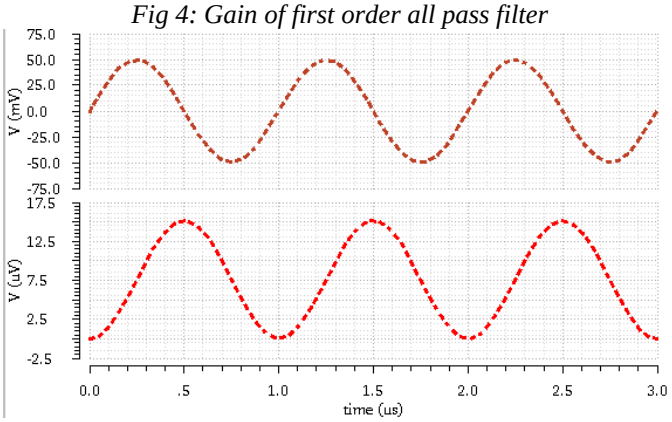

Fig 5: Transient response of second order all pass filter

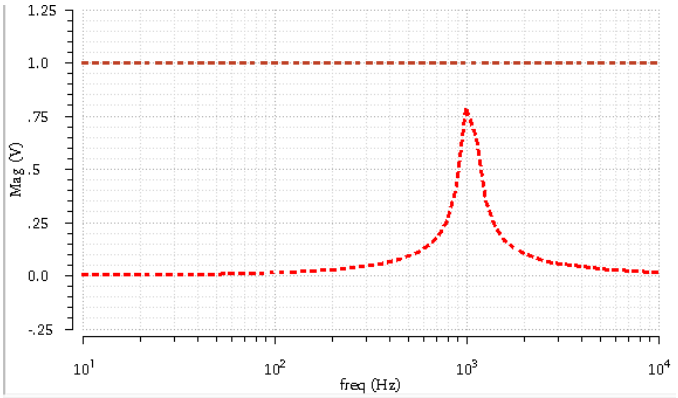

Fig 6: Gain of second order all pass filter

According to all pass filter the output magnitude is same as the input figure (3) shows the input and output magnitude and phase shift which is 90˚ of first order all pass filter. Figure (4) explains about the gain of first order all pass filter and figures (5) and (6) explains the phase, magnitude and gain of second order all pass filter.

4.1.FIR filter using all pass transformation based variable digital filter:

In this we use all pass filters to replace the delay elements of FIR filter and in this we use three different orders to compare the delays of the different order FIR filters.

A.FIR filter with 24 order:

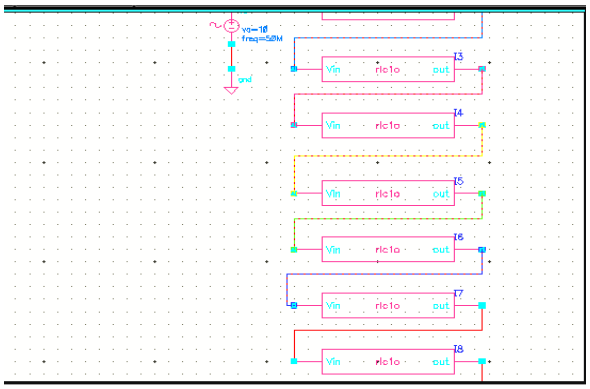

FIG 7: FIR FILTER WITH FIRST ORDER ALL PASS FILTER

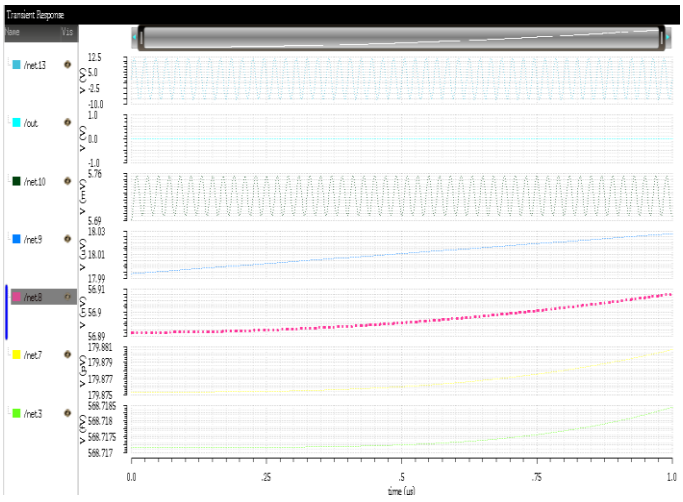

FIG 8: TRANSIENT RESPONSE OF FIR FILTER

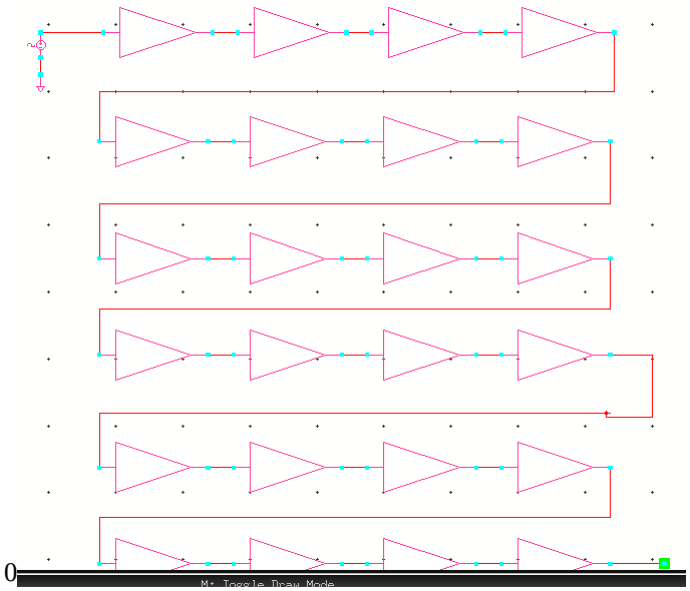

FIG 9: FIR FILTER WITH SECOND ORDER ALL PASS FILTER

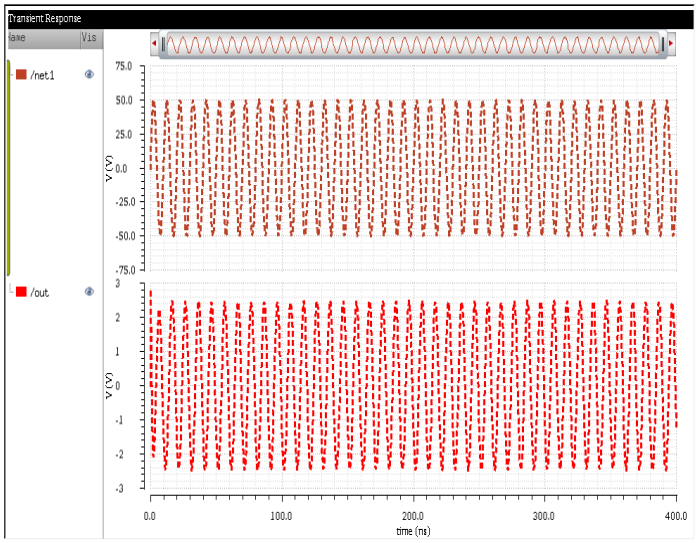

FIG 10: TRANSIENT RESPONSE OF FIR FILTER

Figure (7) shows the schematic of FIR filter with order in which delay elements of FIR filter is replaced by first order all pass filter and figure (8) show the transient response of FIR filter which has higher operating frequency similarly figure (9) shows the FIR filter with 24 order but the delay elements of FIR filter is replaced by second order all pass filter and figure (10) the transient response of FIR

Table 1: first and second FIR filter values

	1st order FIR filter			2nd order filter		
Filter order	24 order	46 order	90 order	24 order	46 order	90 order
Power consumption	14.37 uW	13.6 uW	2.97 uW	21.66 uW	8.255 mW	186.8 nW
Operating frequency (M HZ)	100	100	100	100	100	100

5CONCLUSION (10 PT)

In this we proposed the design of all pass filters both first and second order using RLC circuit. Three different order of FIR filter are designed using all pass transformation based variable digital technique the resultant filter provide high operating frequency, less delay the parameters are-power consumption, operating frequency.

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