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HIGH IMPEDANCE VOLTAGE-MODE MULTIFUNCTION FILTERS IMPLEMENTED BY FTFNs AND OP-AMP

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ABSTRACT

This paper presents a voltage-mode multifunction filter based on and employing two four-terminal floating nullors (FTFNs) and a single operational amplifier (OP-AMP). The high-input impedance voltage-mode configuration can simultaneously realize lowpass (LP), highpass (HP) and bandpass (BP) filtering functions from the same configuration. The circuit employs two grounded capacitors which suits contemporary IC design techniques. High output impedances of the proposed multifunction filter enable the circuits to be cascaded without requiring any impedance matching device. Passive sensitivity figures are low. The theoretical results are confirmed by PSPICE simulations.

Key words: Multi-function filter, Voltage-mode, High impedance, FTFN

1. INTRODUCTION

Multi-function type active filters are especially versatile, since the same topology can be used for different filter functions. Numerous multifunction voltage mode filters containing more than one active current mode element, such as current feedback amplifiers [1], current conveyor [2-3], operational transconductance amplifiers [4], with their well known advantages of providing wide bandwidths and high slow rates are reported in literature. The available literature pertaining to the development of continuous-time circuits shows that four-terminal floating nullor (FTFN) is a more flexible and versatile building block than an operational amplifier (OP-AMP) or a second-generation current conveyor (CCII) [1-4]. But one intrinsic drawback of this block is that it is devoid of programmability feature, which is indispensable from the point of view of IC design consideration, nevertheless the same can be achieved using FTFN in conjunction with single operation transconductance amplifier (OTA).

There has been a growing interest to develop high impedance current- and voltage-mode (VM) filters using active devices like current feedback amplifiers (CFAs), OTAs and FTFNs. As a sequel, a number of current-mode filter circuits employing FTFNs have been reported in the literature [5-13]. Some of VM filter circuits based on FTFN, CCII and OTA have also been reported in the literature [14-22]. A study of the available literature shows that much attention has not been paid towards the development of high-input impedance VM filters based on FTFN. One of the reported circuits [14] based on two FTFNs and five passive components has the limited scope of applicability as it can be configured to implement only one filtering function depending on the selection of passive components.

The main disadvantages of this circuit are that it requires element-matching condition and it can not simultaneously realize low-pass, band-pass and high-pass filter functions with the same topology. However no Single Input Three Output (SITO) voltage-mode multifunction filter which uses FTFNs to realize basic filtering characteristics with high output impedance have been reported in the literature. In this study, a single input three outputs (SITO) voltage-mode multifunction filter using two FTFNs, one OP-AMP and passive elements is proposed. The proposed circuit can simultaneously realize low-pass, band-pass and high-pass filter functions without changing the circuit topology. It does not require any parameter matching condition. Sensitivities to the passive elements are low. All outputs of the filter exhibit high output impedances so that the filters are easily cascadable.

2. THE PROPOSED CIRCUITS

The circuit symbol of the FTFN is shown in Figure-1.a. The positive FTFN can be implemented by cascading two AD844s [23,24] from analog devices

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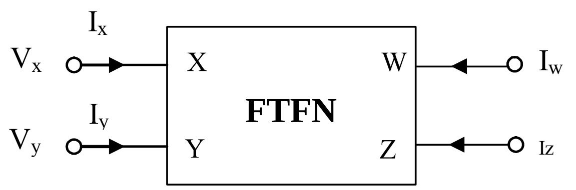
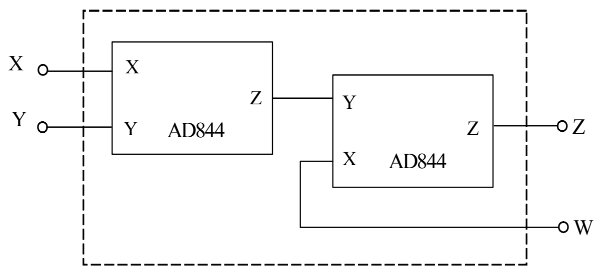
and is shown in Figure-1.b. It's defining equations are

$$V_X = V_Y,\ I_X = I_Y = 0,\ I_W = I_Z \tag{1}$$



(a) Symbol



(b) Realisation

Figure-1 Implementation of FTFN

The analysis of the circuit in Figure-2 yields the voltage-mode High-pass, Low-pass and Band-pass transfer functions as given by

$$\frac{V_{HP}}{V_{in}} = \frac{s^2}{s^2 + \frac{s}{R_1C_1} + \frac{1}{R_1R_2C_1C_2}} \tag{2}$$

$$\frac{V_{BP}}{V_{in}} = \frac{s / R_1C_1}{s^2 + \frac{s}{R_1C_1} + \frac{1}{R_1R_2C_1C_2}} \tag{3}$$

$$\frac{V_{LP}}{V_{in}} = \frac{1 / R_1R_2C_1C_2}{s^2 + \frac{s}{R_1C_1} + \frac{1}{R_1R_2C_1C_2}} \tag{4}$$

The parameters ω_0, ω_0/Q and Q are given by

$$\omega_0 = \sqrt{\frac{1}{R_1R_2C_1C_2}} \tag{5}$$

$$\frac{\omega_0}{Q} = \frac{1}{R_1C_1} \tag{6}$$

$$Q = \sqrt{\frac{R_1C_1}{R_2C_2}} \tag{7}$$

The sensitivity figures are given by

$$S_{R_1}^{w_o} = S_{R_2}^{w_o} = S_{C_1}^{w_o} = S_{C_2}^{w_o} = -1/2 \tag{8}$$

$$S_{R_1}^{Q} = S_{C_1}^{Q} = -S_{R_2}^{Q} = -S_{C_2}^{Q} = 1/2 \tag{9}$$

which are small.

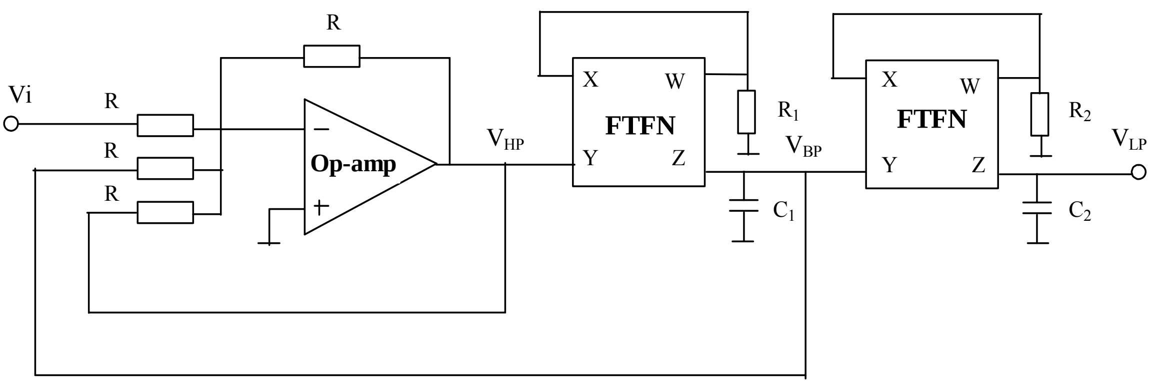


Figure-2 Proposed voltage-mode multifunction filter configuration

3. SIMULATION RESULTS

In order to demonstrate the feasibility of the proposed multi-function filter, SPICE circuit simulations were performed using a FTFNs be implemented by cascading two AD844 and Op-Amp circuit given in Figure-2. To confirm theoreical analysis, the propesed circuit has been simulated using PSPICE program and simulation results are given Figure-3. The circuit was constructed with the commerical current feedback Op-Amp IC AD844 of Analog Devices. The FTFN was implemented with of two AD844 IC as V_{DD}=12V and V_{SS}= -12V. The passive components of the filter were chosen as R=10k, R_1=R_2=10kΩ and C_1=C_2=10nF, which results in a 1.59 Hz center frequency. The PSPICE simulation results given in Figure-3 for the low-pass, high-pass and band-pass filter characteristics verify the theoretical analysis.

Furthermore, to demonstrate the performance of higher order filter which is made up more than one cascaded filter sections, cascaded two and three Band-pass filter sections having the same component values given above for the Band-pass filter are simulated with PSPICE and simulation results are given in Figure.4. Simulation results of the proposed multifunction filter responses are in good agreement with the predicted theory.

To test the input dynamic rang of the proposed filters, the simulation of the low-pass filter as an example has been repeated for a sinusoidal input signal at *fo*≈1.59 kHz. Figure.5 shows that the input dynamic range of the filter response extends up to amplitude of 200mV (peak to peak) without significant distortion. Output amplitude change with load resistance for constant input signal is seen in Figure.6 it is seen that, at 1.59kHz frequency a large swing Vo=11V is obtained at the output.

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4. CONCLUSION

The voltage-mode multifunction filters based on employing two FTFNs and a single Op-Amp. has been presented. The configurations enjoy the following features: Voltage-mode configuration can simultaneously realize Low-pass, High-pass and Band-pass filtering functions from the same configuration at high-input impedance. The circuit employs grounded capacitors which suits contemporary IC design techniques. The high impedances of the topologies in the configuration allow easy cascading for implementing higher-order transfer functions. The circuit has low passive sensitivities. It does not require any parameter matching condition. The simulation results demonstrate that the theoritical and simulation results are in good agreement. The proposed circutis are expected to be useful in analog filtering applications. They provide therefore further possibilities to the designer in the realisation of analogue circuits.

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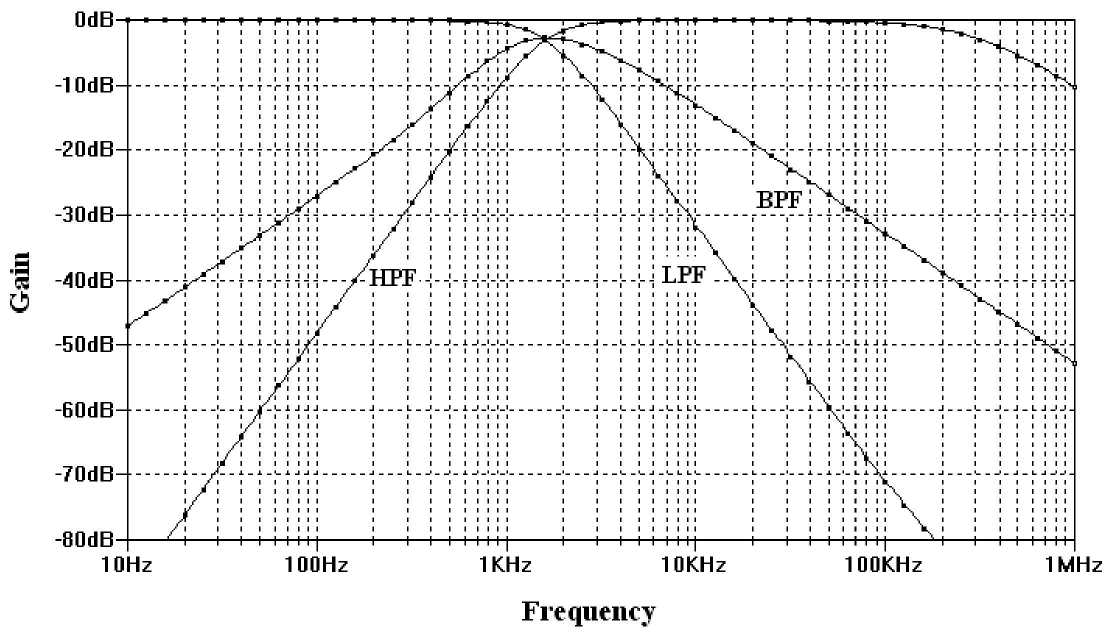

Figure-3 PSPICE simulation results of the proposed multifunction filter

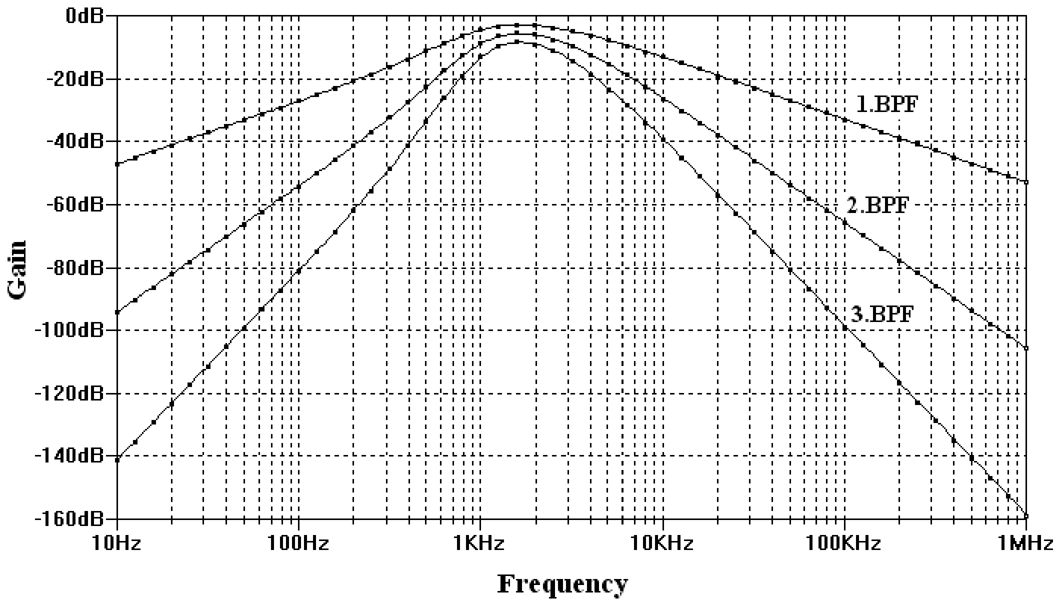

Figure-4 PSPICE simulation results for the cascaded BP filter sections

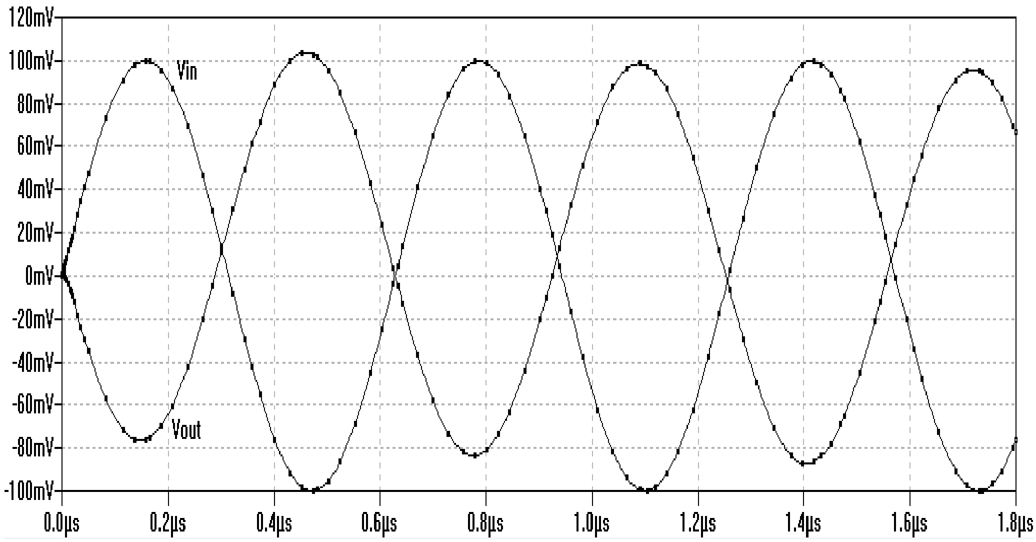

Figure-5 The input and output waveforms of the low-pass filter of for 1.59kHz sinusoidal input current of 200mV (peak to peak)

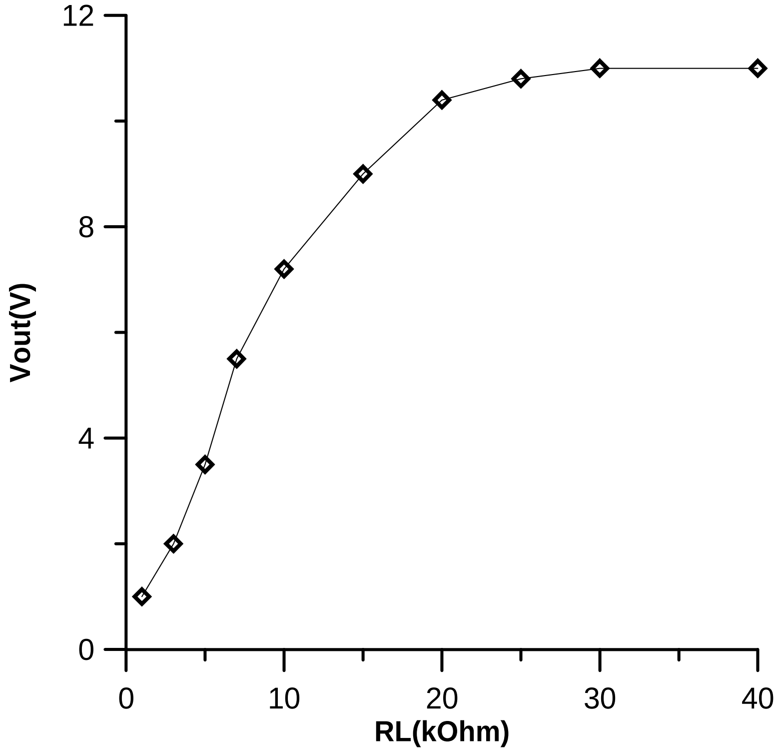

Figure-6 Large signal response of the low-pass filter output amplitude change with load resistance for constant input signal

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