Asian Resonance

Low Pass Analog Filter Using Log-Domain Technique

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Abstract

A novel second order log-domain lowpass (LP) filter based on integrator loops and grounded capacitors is presented. The circuit uses nonlinear nature of the transistor, thereby acquiring wider dynamic range at low power supply, higher frequency operation, and simpler circuit architecture. The circuit enjoys electronic tunability of all the parameters in an independent but sequential manner. PSPICE simulations are included.

Keywords: Analog Signal Processing, Log-Domain Filter, Current-Mode Filters.

Introduction

The current research interest in the field of analog signal processing is the design and development of continuous-time log domain filters (CTF) which utilize the transistor non-linearity to implement the intended function. The idea of filtering in Log-domain introduced by Adams in the late 1970s [1] is based on the use of log and anti-log techniques in conjunction with the combination of forward biased diodes and a capacitor. Some related concepts were employed to develop log domain filters which include companding techniques [2-4] state space techniques [5] and integrator loops [6].

These filter topologies offer the following potential advantages over the conventional continuous-time filters: low-voltage operation, superior noise performance, higher frequency applications, larger dynamic range, electronic tunability and efficient possible circuit topologies [4,7]. Moreover these filters use grounded capacitors which are ideal for integration [8].

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The Log-domain approach uses exponential current versus voltage characteristics of a transistor in which collector current is related to base-emitter voltage by

$$I_c = I_s exp(V_{be}/V_T)$$

where Is is the saturation current, $V_T = kT/q = 26mV$ at room temperature. Thus log domain filters use only transistors and grounded capacitors, thereby making their implementation simpler and amenable in contemporary IC design techniques.

In this paper, we present a new LP Log-domain filter. The filter is based on and employs simple and damped integrators, current sources and grounded capacitors. The proposed filter offers independent but sequential adjustment of the parameters through separate bias currents.
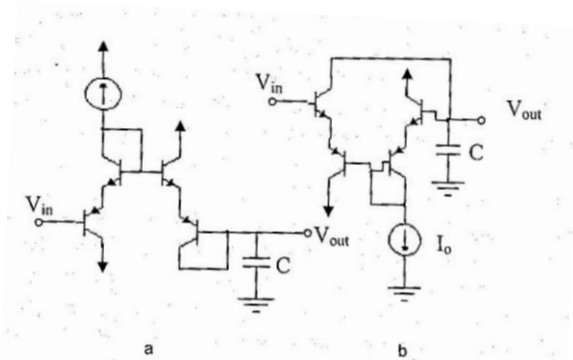
Proposed Circuit

A log-domain filter is one that uses nonlinear building blocks to obtain linear filtering functions and is based on the main concept of the exponential relation between the collector current and base-emitter voltage of a bipolar junction transistor (BJT). The transconductance block is subject to the following relation

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$$I_{out} = I_o \exp\left(\frac{V}{2V_T}\right) \qquad (1)$$

Inverting and non-inverting type integrators which are employed to construct the proposed filter are respectively shown in Figure 1(a) and 1(b), the current through the capacitor is given by

$$C\frac{dV_o}{dt} = I_o \exp\left[(V_{in} - V_o)/2V_T\right] \qquad (2)$$

Fig(1):- (a) Inverting and (b) Non-inverting integrators

In order to obtain linear filtering function the use of log-in and log-out circuits shown respectively in Figure 2 (a) and 2 (b) are needed.
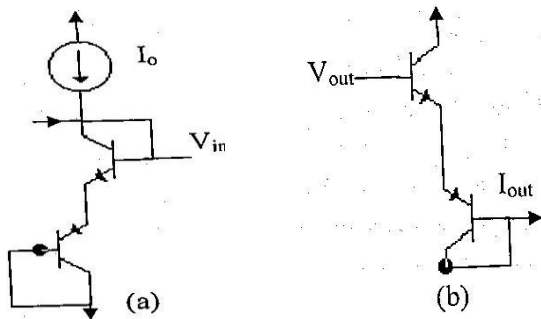

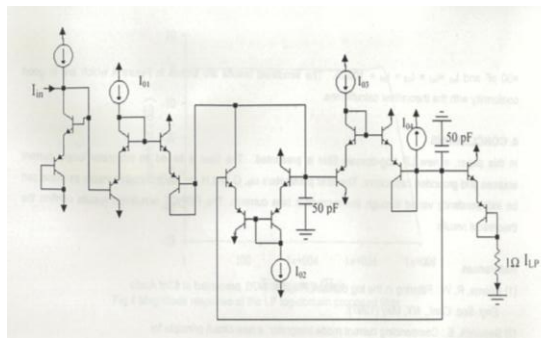
Figure 2 (a) Log-input and (b) Log-output

Fig.3 Proposed Log-domain Low-pass filter

The proposed filter shown in Figure 3 based on the blocks depicted in Figures (1) and (2), yields the following current-mode transfer function:

$$T_{LP} = \frac{H\omega o^2}{S^2 + S\dfrac{\omega o}{Q} + \omega o^2} \qquad (3)$$

where pole frequency (ω_o), quality factor (Q)and gain (H)are given by

$$\omega_o = \frac{1}{2V_T}\sqrt{\frac{I_{o2}I_{o3}}{C_1 C_2}} \qquad (4)$$

$$Q = \frac{1}{I_{o4}}\sqrt{\frac{I_{o2}I_{o3}C_2}{C_1}} \qquad (5)$$

$$H = \frac{I_{o1}}{I_{o2}} \qquad (6)$$

From equations (4) to (6) one can see that the filter parameters are tunable through the respective biasing currents. The pole frequency ω_o can be adjusted through I_{o2} or I_{o3} and Q by I_{o4} without disturbing ω_o. Moreover, H can be tuned by I_{o1} without disturbing ω_o and Q. Thus the circuit has independent programmability features.

Simulation Results

PSPICS simulation was performed to check the workability of the proposed filter. The circuit was designed for a frequency of 6.3 MHz, Q = 1 and H = 1, leading respectively to the capacitor and current values $C_1 = C_2 = 50$ pF and $I_{o1} = I_{o2} = I_{o3} = I_{o4} = 100\mu A$. The simulated results are shown in Figure 4 which are in good conformity with the theoretical calculations.

Conclusions

In this paper, a new LP Log-domain filter is presented. The filter is based on integrator loops, current sources and grounded capacitors. The filter parameters ω_o, Q and H are electronically tunable as these can be independently varied through the respective bias currents. The PSPICE simulation results confirm the theoretical results.

References

1. Adams, R. W.: Filtering in the log domain. *Preprint 1470, presented at 63rd Audio Eng. Soc. Conf., NY,* May (1997).
2. Seevinck, E.: Companding current mode integrator: a new circuit principle for continuous time monolithic filters. *Electronics Letters.* Vol. 26, (1990) 2046-2047.
3. Tsividis, Y.; Li, D.: Current-mode filters using syllabic companding, *Proc. IEEE ISCAS.* (1996)121-124.
4. Tsividis, Y.: Minimizing power dissipation in analogue signal processors through syllabic companding. *Electronics Letters.* Vol. 35, (1999) 1805-1807.
5. Frey, D.; Tola, A.: A state space formulation for externally linear class AB dynamical circuits. *IEEE TC AS-II.* Vol. 46, (1999).
6. Wu, J.; El-Masry, E. I.: Log-domain synthesis of an nth-order filter. *Int. Journal of Electronics.* Vol. 84, (1998) 359-369.
7. Perry, D.; Roberts, G.W.: Log-domain filters based on LC ladder synthesis. *Proc.1995 IEEE ISCAS.* Vol. 1, (1995) 311-314.
8. Kircy, A.; Cam, U.: A novel first-order log-domain allpass filter. *AEU Int. Journal of Electronics and communication.* Vol. 60, (2006) 471-474.
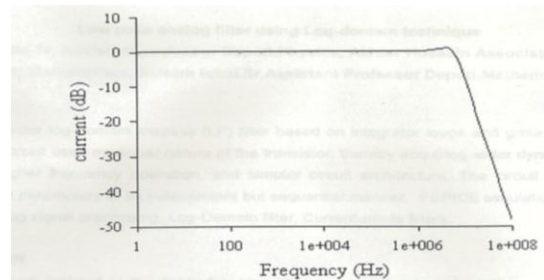
Fig.4 Magnitude response of the LP log-domain proposed filter