# CDBA-Based Electronically Tunable Filters and Sinusoid Quadrature Oscillator

R. Nandi, P. Venkateswaran, Soumik Das and M. Kar

**Abstract**—— New Current Differencing Buffered Amplifier (CDBA) - based multifilter function topologies are presented. Electronic tuning is derived by appropriate insertion of a multiplier element whose control voltage ($V_c$) tunes the select frequency in a range of 200KHz ≤ fo ≤ 1MHz. The circuits also realize a voltage controlled quadrature oscillator (VCQO) with suitable design. Analysis on the effects of the CDBA-parasitic components indicates low active-sensitivity and good frequency-stability of the oscillator. The multifunction performance has been verified both with PSPICE macromodel simulation and by hardware circuit tests. A novel method of measuring the oscillator frequency-tuning error ($\Delta f$) based on the Nyquist plot is presented that shows $\Delta f \approx 2\%$.

**Index Terms**— CDBA · Electronic tuning · Quadrature oscillator · Selective filters

## 1 Introduction

The Current Differencing Buffered Amplifier (CDBA) element, introduced in the recent past as a versatile active building block [1], is now being widely used for various analog signal processing/conditioning and wave generation applications [2], [3], [4], [5], [6]. The element has various advantageous features [1], viz., improved bandwidth, fast settling time and high slew rate. The CDBA offers accurate unity port-transfer ratios when it is being configured by a pair of readily available current feedback amplifier (CFA-AD844 or OPA-2607 dual pack) device; recently some improved models of CFA (OPA-695) are being made available with bandwidth (BW) of 1.4 GHz and slew-rate of 2.5KV/ $\mu$s [7], [8]. Function circuits based on the CDBA are easily cascadable owing to the availability of output nodes both in voltage source and current source modes. Its accurate port tracking characteristics leads to extremely low circuit sensitivity [3], [4], [5].

A number of CDBA-based active filter and oscillator implementation schemes are now available in the literature [1], [2], [3], [4], [5], [6] but none had as yet presented any design on the electronic tunability of high quality filters and quadrature sinusoid oscillator. Albeit electronically tunable function circuit design schemes based on other active elements, viz., CDTA [9], CMOS-LC component [10] and CCCII-OTA [11] had been recently reported, the CDBA based designs are gaining significant research interest owing to very low active sensitivity feature while being adaptable to monolithic implementation with bipolar and CMOS technologies [1], [2], [3].

We present here a new CDBA-based realization of electronically tunable bandpass(BP)/lowpass(LP) filters and voltage controlled quadrature oscillator (VCQO). The proposed circuit uses the CDBA building block along with a multiplier (ICL-8013) element inserted suitably in the circuit-loop. The d.c. control voltage ($V_c$) of the multiplier tunes the select frequency $(\omega_0)$ while the selectivity (Q) can be independently adjusted by a resistor-ratio. These functions have been experimentally verified in a frequency range of $200KHz \le f_0 \le 1MHz$ with good selectivity $(Q \approx 12)$; both hardware circuit results and PSPICE [12] simulated responses are included. By appropriate interchange of some RC components in the circuit topology, a highpass (HP) filter response can also be obtained. The proposed circuits use only one external capacitor for a second-order function realization, since the parasitic z-node capacitance had been utilized as the other; thus economizing on the capacitor count.


- *R. Nandi , corresponding author is with the Department of ETCE, Jadavpur University, Kolkata, 700032, W.B., India. E-mail: robnon@ieee.org, rnandi@etce.jdvu.ac.in.*
- *P.Venkateswaran is with the Department of ETCE, Jadavpur University, Kolkata, 700032, W.B., India.*
- *Soumik Das is with the Department of AEIE, Heritage Institute of Technology, Kolkata, 700107, W.B., India.*
- *M. Kar is with the Department of ECE, Heritage Institute of Technology, Kolkata, 700107, W.B., India.*


## 2 Analysis

The CDBA is a four-terminal active building block with the following terminal relations

$$\begin{bmatrix} i_z \\ v_w \\ v_p \\ v_n \end{bmatrix} = \begin{bmatrix} 0 & 0 & \alpha_p & -\alpha_n \\ \delta & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} v_z \\ i_w \\ i_p \\ i_n \end{bmatrix} \quad (1)$$

The circuit symbols and the CFA- based