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Quadrature oscillator employing VDIBA with Grounded passive elements

[1]Anagha Narwade,[2]Ramnish kumar

M.Tech. scholar,[2]Associate Professor,
[1,2]Electronics & Communication Engineering,
Guru Jambheshwar University of Science and Technology, Hisar,India

Abstract: In the present paper the quadrature oscillator employing VDIBA with two grounded capacitors and one grounded resistor is introduced. The offered design makes use of all grounded capacitors and resistor, making it suitable for implementation of IC.The proposed structure has two advantages: 1) independent control of oscillation frequency and condition, and 2) low active and passive sensitivity. The impacts of VDIBA non-idealities on the proposed oscillator were further examined. PSPICE simulation has proven the feasibility of the suggested configuration with TMSC 0.18μm process parameter. The simulation results confirmed the theoretical concepts.

IndexTerms: Quadrature oscillator, VDIBA.

I. INTRODUCTION

Handful of studies relative to innovative circuit ideas of active blocks for fast analogue signal processing has been constantly increasing since approximately the year 2000.several modern active building blocks are introducedfor example CDBA, CDTA, CCII, MCCII,FTFN, OTA, VDIBA etc. in [1].The active building block (ABB) presented in active devices for electronics and electrical engineering is appropriate for a class of analogue signal processing using voltage-mode and current-mode techniques. Furthermore, in order to assist in the design of a circuit and reduce the number of passive devices used in the design process, ABB development has been required to be more qualified, such as increasing parasitic resistances at input terminals, increasing the number of input and output terminals, and so on [6].The oscillator is a fundamental building block that is widely utilized in electrical and electronics engineering [2].Quadrature oscillators are oscillators that create two waves with a 90-degree phase difference between them. The sine and cosine signals generated by a quadrature oscillator are equally spaced in phase and have the same magnitude, which is useful in telecommunications for single-sideband generators and quadrature mixtures, as well as for measurement in selective voltmeters or vector generators.As a result, quadrature oscillators play an important role in many communication and instrumentation systems[3,4,5,8,9].Implementing active filters and oscillators has become an important analysis topic in analogue circuit design [7].BiolekSenani previously introduced a number of advance active building blocks [1] VDIBA is among them, and it is emerging as a very flexible and versatile building block for analog signal processing and signal generation, having previously been used to realize a variety of functions [10].VDIBA has also been utilised to develope a quadrature oscillator that does not use a grounded resistor. As a result, the goal of this work is to create a quadrature oscillator with independent control of the oscillation condition and frequency utilising grounded resistors and grounded capacitors.

This paper introduces a quadrature oscillator using VDIBA with a minimal number of grounded passive elements, which offers independent control of oscillation frequency and condition of oscillation.The proposed circuit employs one VDIBA as active element and two grounded capacitors and one grounded resistor. The presented circuit is suited for integrated circuit implementation due to the usage of grounded capacitors and resistor [4].

II. PROPOSED CIRCUIT

VDIBA is a four terminal active building block with two highimpedance voltage inputs V_+ and V_-, a high-impedance current output I_z and a low-impedance inverting voltage output V_{w-}[11]. The following hybrid matrix can characterize its voltage-current characteristics [12].

$$\begin{bmatrix} I_{V+} \\ I_{V-} \\ I_Z \\ V_{W-} \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ g_m & -g_m & 0 & 0 \\ 0 & 0 & \beta & 0 \end{bmatrix} \begin{bmatrix} V_{V+} \\ V_{V-} \\ V_Z \\ I_{W-} \end{bmatrix}$$

From the above matrix the ideal terminal equations between voltages and current are as expressed as $I_+ = I_- = 0$, $I_Z = gm(V_+ - V_-)$ and $V_W = -V_Z$[12]. Where β is a non-ideal voltage gain of the VDIBA. The value of β in an ideal VDIBA is unity. Figure 1 shows the schematic symbol and equivalent circuit of VDIBA [13].

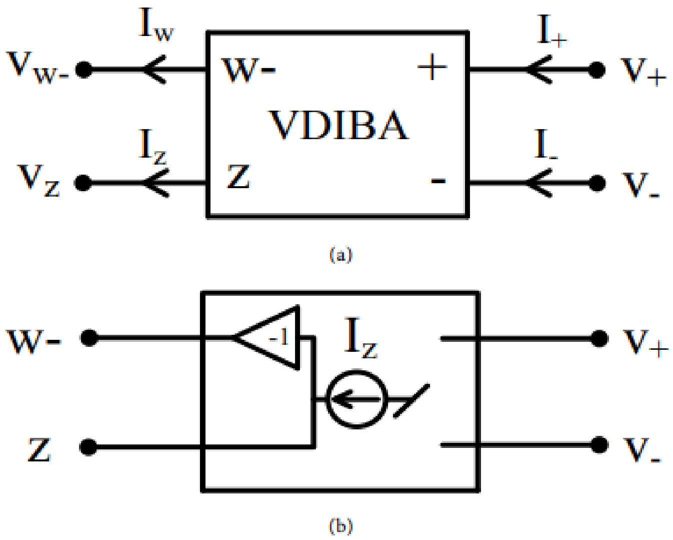

Fig 1: (a) schematic symbol (b) equivalent circuit of VDIBA

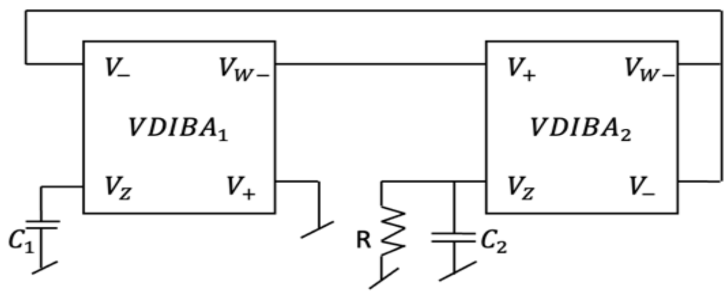

Fig 2: Proposed quadrature oscillator

The circuit analysis of the proposed configuration in figure 2 produces the characteristic equation presented below.

CE: $S^2C_1C_2R + SC_1(1 - gm_2R) + gm_1gm_2R = 0(1)$

The oscillation condition OC and frequency FO can be calculated using Equation (1), as follows:

$$\text{CO: } 1 \leq gm_2R(2)$$

And

$$\text{FO: } \sqrt{\frac{gm_1gm_2}{C_1C_2}}(3)$$

III. NONIDEAL ANALYSIS

Considering R_{z1},$R_{z2}$and C_{Z1} as parasitic resistance and parasitic capacitance respectively of the Z-terminal of the VD-DIBA, taking the non-idealities into account, namely the voltage of W- terminal V_W = -βV_Z where $\beta = 1 - \epsilon_p$ ($\epsilon_p \ll 1$) denote the voltage tracking errors of Z-terminal and V-terminal of the VD-DIBA respectively[15], then the expressions for CE, CO and FO can be given as:

CE:

$$S^2(C_1C_2 + C_1C_{z2} + C_{z1}C_2)+ S\{\frac{1}{R}(C_2 + C_1 + C_{Z1}) + \frac{1}{R_{Z2}}(C_1 + C_{Z1}) + \frac{C_1}{R_{Z2}} - gm_2\beta(C_1 + C_{Z1})\} + \frac{1}{R_{Z1}}\left(\frac{1}{R} + \frac{1}{R_{Z2}} - gm_2\beta\right) + gm_1gm_2\beta^2 = 0(4)$$

Therefore expression for CO and FO from equation (4) given as follows, CO: $\{\frac{1}{R}(C_2 + C_1 + C_{Z1}) + \frac{1}{R_{Z2}}(C_1 + C_{Z1}) + \frac{C_1}{R_{Z2}} - gm_2\beta(C_1 + C_{Z1})\} \leq 0$ (5)

And

FO: $\sqrt{\frac{R_{Z2}+R+gm_2\beta RR_{Z2}(1+gm_1\beta R_{Z1})}{RR_{Z1}R_{Z2}(C_1C_2+C_1C_{Z2}+C_2C_{Z1}+C_{Z1}C_{Z2})}}$ (6)

IV. SENSITIVITY ANALYSIS

One of the important parameters of oscillator circuits is the sensitivity of frequency ω to passive components. The sensitivity of frequency ω to any passive component is defined as follows.

$$S_X^{\omega} = \frac{X}{\omega}\frac{d\omega}{dX} \quad (7)$$

Where ω denotes the angular frequency and x denotes any passive component [17]. The active and passive sensitivities can be calculated as follows by considering $C_{Z1} = C_{Z2} = C_Z$ and $R_{Z1} = R_{Z2} = R_Z$

$$S_{C1}^{\omega} = -\frac{1}{2}\frac{C_1(C_2 + C_Z)}{C_1C_2 + C_1C_Z + C_2C_Z + {C_Z}^2}$$

$$S_{C2}^{\omega} = -\frac{1}{2}\frac{C_2(C_1 + C_Z)}{C_1C_2 + C_1C_Z + C_2C_Z + {C_Z}^2}$$

$$S_{CZ}^{\omega} = -\frac{1}{2}\frac{C_Z(C_1 + C_2 + C_Z)}{C_1C_2 + C_1C_Z + C_2C_Z + {C_Z}^2}$$

$$S_{R}^{\omega} = -\frac{1}{2}\frac{R_Z}{R_Z + R + gm_2\,\beta\,R(gm_1\beta {R_Z}^2 - R_Z)}$$

$$S_{R_Z}^{\omega} = -\frac{1}{2}\frac{2R_1 + gm_1gm_2R{R_Z}^2\beta^2}{R_Z + R + gm_2\,\beta\,R(gm_1\beta {R_Z}^2 - R_Z)}$$

$$S_{gm_1}^{\omega} = \frac{1}{2}\frac{gm_1gm_2R{R_Z}^2\beta^2}{R_Z + R + gm_2\,\beta\,R(gm_1\beta {R_Z}^2 - R_Z)}$$

$$S_{gm_2}^{\omega} = \frac{1}{2}\frac{gm_2RR_Z\beta}{R_Z + R + gm_2\,\beta\,R(gm_1\beta {R_Z}^2 - R_Z)}$$

$$S_{\beta}^{\omega} = \frac{1}{2}\frac{R_ZR(gm_1gm_2R_Z - gm_2)\beta}{R_Z + R + gm_2\,\beta\,R(gm_1\beta {R_Z}^2 - R_Z)}$$

In ideal case sensitivity of frequency ω to passive elements is observed as

$$S_{C1}^{\omega} = S_{C2}^{\omega} = S_{R1}^{\omega} = S_{CZ}^{\omega} = S_{RZ}^{\omega} = -\frac{1}{2}, S_{gm_1}^{\omega} = S_{gm_2}^{\omega} = S_{\beta}^{\omega} = \frac{1}{2}$$

For typical values of $C_Z = 0.81$nf, $R_Z = 53$kΩ, $\beta = 1$ along with $C_1 = C_2 = 1$nf, $R = 3$kΩ and $gm_1 = gm_2 = 600$μS various sensitivities are found to be $S_{C1}^{\omega} = -0.391$, $S_{C2}^{\omega} = -0.276$, $= -0.533$, $S_R^{\omega} = 0.516$, $S_{RZ}^{\omega} = -0.507$, $S_{gm_1}^{\omega} = 0.5$, $S_{gm_2}^{\omega} = 0.015$, $S_{\beta}^{\omega} = 0.49$ which all are quite low.

V. SIMULATION RESULT

To validate the theoretical study, the proposed circuit has been simulated using the CMOS-based VDIBA shown below in figure 3, which was biased with $V_{DD} = -V_{SS} = 0.9$V and $I_b = 100$ μA. [14].

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The passive components values used were C_1=C_2=1nf and R_1=3khz. The transconductance of $VDIBA_s$ were controlled by respective bias current I_b.The SPICE generated output waveforms indicating transient and steady state responses are shown in figure 4 and figure 5 respectively. As a result, the legitimacy of the proposed configuration is confirmed. figure 6 gives the frequency spectrum of proposed quadrature oscillator. CMOS VDIBA is implemented using TMSC 0.18µm technology. Aspect ratios of MOSFETs is shown in Table 1 and Table 2 presents a comparative study with other known Quadrature oscillators that use VDIBA as active building block.

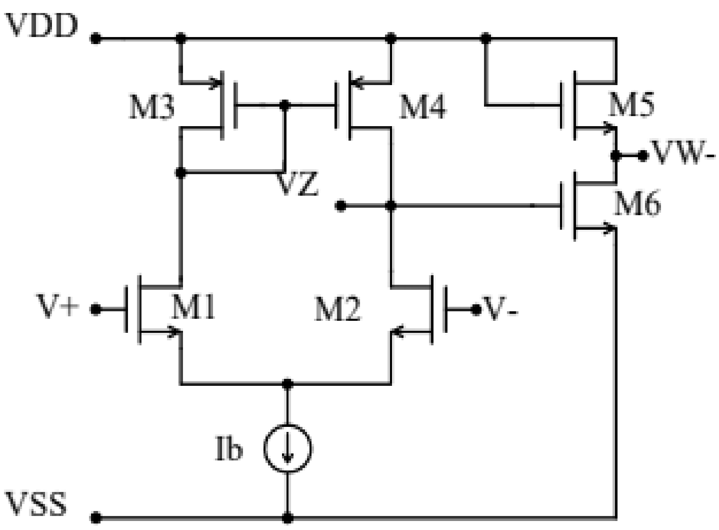

Fig 3: CMOS implementation of VDIBA

Table. 1: The aspect ratios of MOSFETs [15]

Transistor	W(µm)	L(µm)
M1-M4	18	1.08
M5-M7	54	0.18

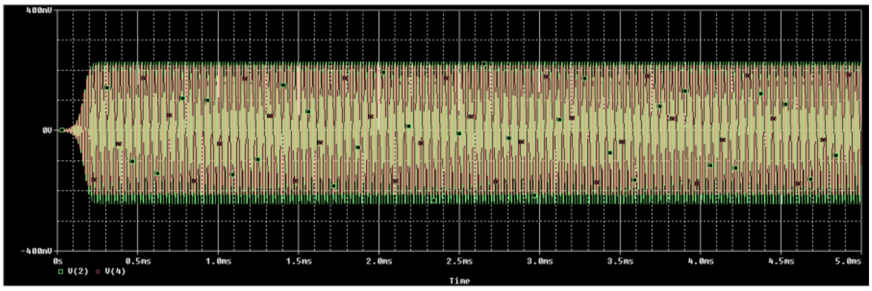

Fig 4: transient output

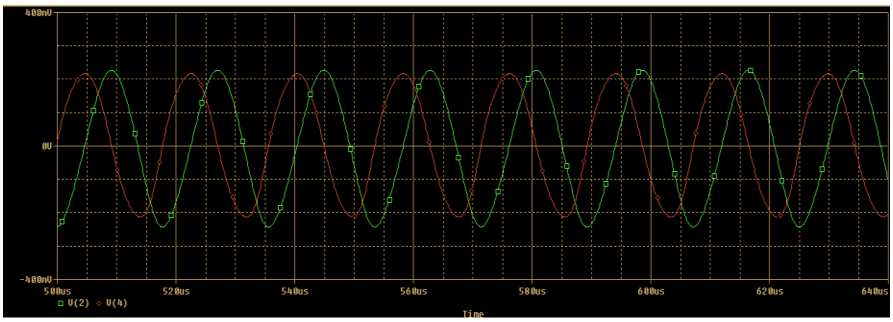

Fig 5: steady state output

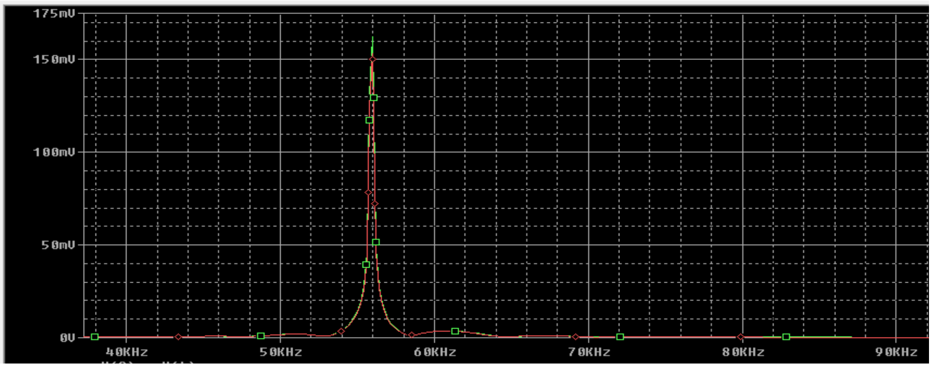

Fig 6: Frequency response

VI. CONCLUSION

In this study quadrature oscillator having independent control of frequency of oscillation and and oscillation condition is presented.The presented quadrature oscillator uses only two VDIBAs,two grounded capacitors and one grounded resistor. The designed circuit's oscillation condition and frequency of oscillation are controlled by the transconductance of the VD-DIBAs and resistor employed in configuration.PSPICE simulations using 0.18 m TMSC technology were used to demonstrate the feasibility of the suggested structure.The proposed configuration offers the benefit of low transistor count therefore; it has simplicity in its structure.

Table 2: Comparison of previously known quadrature sinusoidal oscillators.

	Proposed	**Reference [16]**	**Reference [15]**
CMOS technology	$0.18\mu m$	$0.18\mu m$	$0.18\mu m$
Supply voltage	$\pm 0.9V$	$\pm 0.9V$	$\pm 0.9V$
Bias current	$I_{b1} = I_{b2} = 100\mu A$	$I_{b1} = I_{b2} = 135.9\mu A$	–
Name and number of active elements	VDIBA(2)	VDIBA(2)	VDIBA (2)
No of passive elements	3	4	2
No of grounded capacitors	2	3	1
Transconductance(g_m)	600µS	–	440µS
Independent electronic tunability in both CO and FO	YES	YES	YES

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