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Design of Current Mode Full wave Rectifier and Current Feedback Operational Amplifier

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Abstract: *In this paper current mode full wave rectifier and feedback operational amplifier is presented.Thisassembly of CMOS is simulated on using Cadence Virtuoso simulation software with its gpdk180 model, i.e.0.18_m technology. Layout of the design is also presented for integration of the circuit.The proposed CurrentFeedback Operational Amplifier (CFOA) is working on the current mode as well as voltage mode techniquesalso. The CFOA design has benefits of gain bandwidth independency compared to the conventional voltagemode operational amplifier.Design of CFOA is implemented using 180nm technology process and simulationis done on the cadence virtuoso software.Rectifier works properly up to 20 MHz frequency.*
Keyword: *Cadence Virtuoso,CFOA,gpdk180 model.*

I. Introduction

Rectifiers play an important role in analog signal processing, AM signal detection, polarity detection, peak detectionand average finder etc. For signal processing, conditioning and recreation of small signals the precisionrectifiers are very important. Full wave rectifiers are also used in DC converters, watt- meters, AC voltmeters, RFmodulators and many non linear analog signal processing. The traditional diode rectifiers are limited, they onlybe used in some fixed applications, like DC voltage suppliers where DC is obtained by AC source. [1–8]

In the modern technology advancements industries and circuits designers are taking interests in current modebecause of its potential advantages over voltage mode. In current mode there are several advantages which areabsent or cannot be overcome in voltage mode, i.e. gain and bandwidth independency over each other withinspecific frequency range is possible, another main advantages are low power consumption, wider bandwidth,larger dynamic range, and low number of components compared with voltage mode. [9–14]

The presented circuit consists of active elements, and no passive elements like resisters, capacitors or diodes.As there are no diodes used then the problem with traditional rectifiers based on diodes, the forward amplifiershad to recover the small signals, resulting in the distortions in the zero crossing of input signal. [9, 11, 15]

We can verify the ouput of CFOA by matrix as follows

$$\begin{bmatrix} I_y \\ V_x \\ I_z \\ V_o \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} V_y \\ I_x \\ V_z \\ I_o \end{bmatrix}$$

Fig. 1 Matrix for CFOA Equations

II. Design Methodology

2.1 FullWave Rectifier:

The design of rectifier is completely based on simple current mirrors assembled in cascoded manner. In the circuitonly MOSFETs are used so that there are no passive components. Because of the transistors the problem whichwas faced during the conventional diode rectifiers is eliminated. The MOSFETs here are working as diodes tocopy the current to next circuit. This design is made to work properly of almost 20MHz frequency. To improvethis buffer and current mirrors can be added to the assembly. The proposed circuit design is as follows

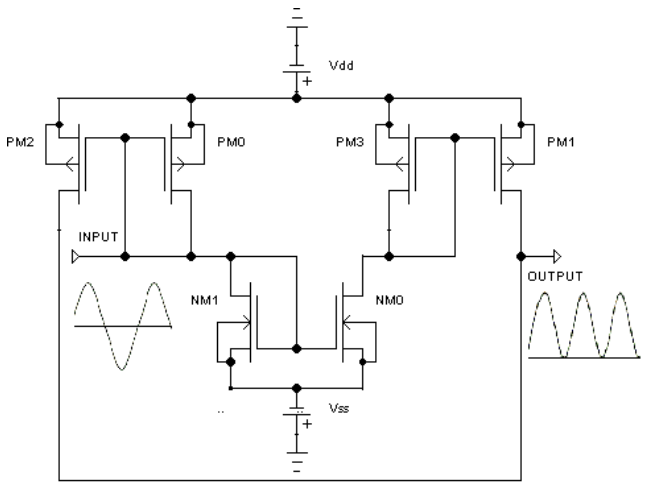

Fig. 1. Current Rectifier

2. CFOA:

A CFOA is made by three fundamental stages:a transconductance stage and two buffers. Specifically, in the firstbuffer whose input and output is connected to inverting and non-inverting inputs of CFOA makes input stage. Thetransconductance stage is second stage and will be responsible to determine the gain of the amplifier and otherbuffer stage is only for the proper driving of output load connected. In the input buffer two current mirrors arepresent, one is pmos type and another one is nmos current mirror, to forward smooth current flow to the next stagewithout any losses. In between the buffers as there is transconductance amplifier which is the assembly of multiplecurrent conveyors of second generation is used to drive and amplify the signals. The third stage i.e output bufferis used to rescue the CFOA from loading effects.

III. Proposed Design

1. FullWave Rectifier

The proposed design is based on three current mirrors in cascoded manner in which two are pmos type mirror andanother on is nmos type. The proposed design is made by using the model file from Cadence Virtuoso simulationsoftware, which can be directly implemented to make Integrated circuits. We have also designed these circuits usingthe model parameters from TSMC 180nm device model, which gives the ideal outputs of the rectifiers with zeropercent loss.

As for positive cycle of current, PM2 and PM0 are getting off whereas the current is transferred through NM1and NM0 transistors as shown in fig. 1 and 2. Similarly for negative half cycle of the current PM2 and PM0 areswitched on and current is directly transferred in opposite sign from PM2 transistor and output is obtained by boththe outputs from PM2 and PM1 transistor.The output equations of the circuit are as follows

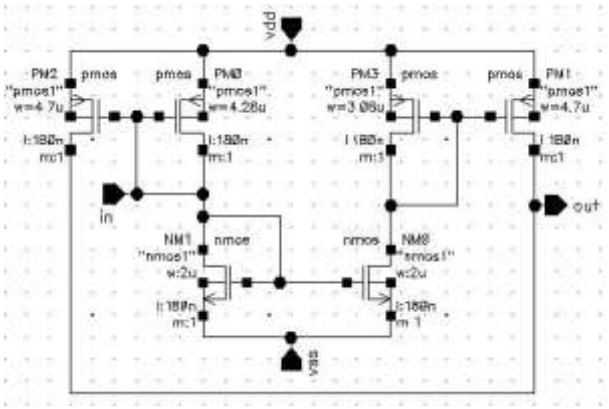

Fig. 2: Current Rectifier in Cadence

$$\mathbf{I}_{out} = I_+ + I_- = \mid I_{in} \mid$$

where

$\mathbf{I}_+ =$ Current through transistor PM1

$\mathbf{I}_- =$ Current through transistor PM2

$$\mathbf{I}_+ = \begin{cases} \mathbf{I}_{in} & \mathbf{I}_{in} \geq 0 \\ \mathbf{0} & \text{otherwise} \end{cases}$$

$$\mathbf{I}_- = \begin{cases} \mathbf{-I}_{in} & \mathbf{I}_{in} \leq 0 \\ \mathbf{0} & \text{otherwise} \end{cases}$$

It can be noted that by changing the values i.e. aspect ratios of the transistors especially PM2 and PM1 themagnitude of Iout can be set to any value. We have designed the rectifier for current of in between 10uA to 40uAi.e. it is linear in between this range, to work on higher value of current the aspect ratio of transistors can bechanged. The values of W/L ratios for the presented rectifier are given in the following table.

Table 1: W/L ratios of Rectifier

Transistor	W/L ratios(um)
Pmos1,Pmos2	4.7/0.18
Pmos0	4.28/0.18
Pmos3	3.15/0.18
Nmos1,Nmos0	2/0.18

2. CFOA

As above stated CFOA consist of three stages i.e input output and middle amplifier. We have used the TSMCl8Onm technology to make this operational amplifier using Cadence Virtuoso. The circuit consists of multiple transistors of different configurations, and different width to length ratios. Thelength to width ratios used are as shown in below table. The expression for input impedance is as follows [2]

$$R_X = \frac{1}{\sqrt{8C_{ox}\mu\frac{W}{L}I_0}}$$

Here, μCox = 1200μ, I_0 = 120 μA and$\frac{W}{L} = \frac{60}{0.18}$Then the value of Rx ≈ 50Ω

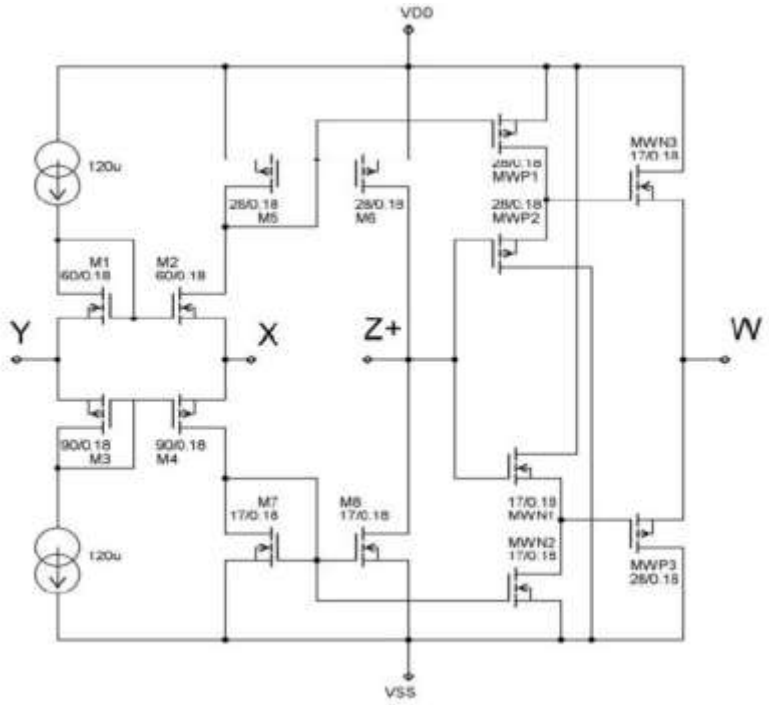

Fig.3 CFOA

Table 2: MOSFET W/L ratios

MOSFET	W/L ratio(um)
M1,M2	60/0.18
M3,M4	90/0.18
M5,M6	28/0.18
M7,M8	17/0.18
MWP1,MWP2,MWP3	28/0.18
MWN1,MWN2,MWN3	17/0.18

IV. Simulation Results

1. Full Wave Rectifier:

We have verified the rectifier using the cadence simulation software and designed it using cadence gpdk180 modelusing 180nm technology. By the simulation results we have found that the given circuit is rectifying the currentsignal with high accuracy and high efficiency.

The input is taken as a sine wave signal of 10uA and 20kHz signal at the input of the circuit and found that the presented aspect ratios of the transistors are best for low current and mid frequency range signals, as seen from the fig. 4 the rectified output is of 9.99uA and input given was of 10uA. Note that rectifier is working on dual supply with supply voltage of 370mV in this circuit.

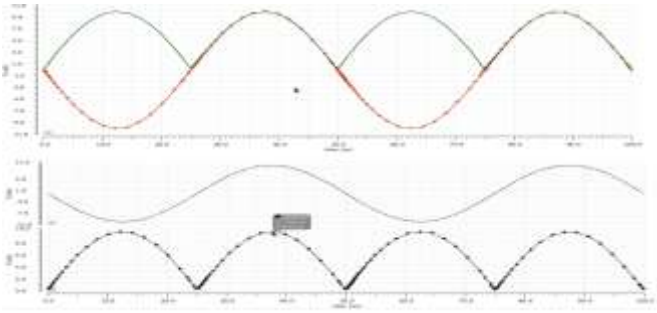

Fig. 4 Full Wave Rectifier Output

2. CFOA:

We have verified the working of CFOA by using the four equations stated in the matrix above,y using DC analysis done on cadence virtuosos simulation software.Theeqautions are Ix=Iz,Iy=0,Vx=Vy,Vz=Vw.

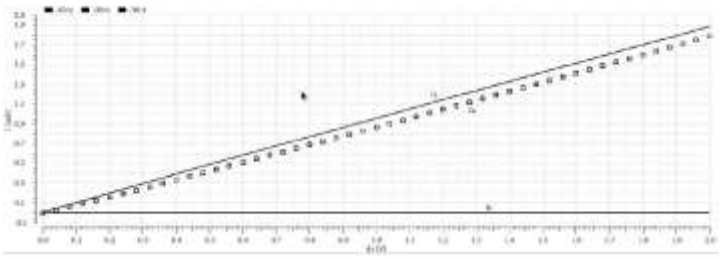

Fig. 5 Ix=Iz ,Iy

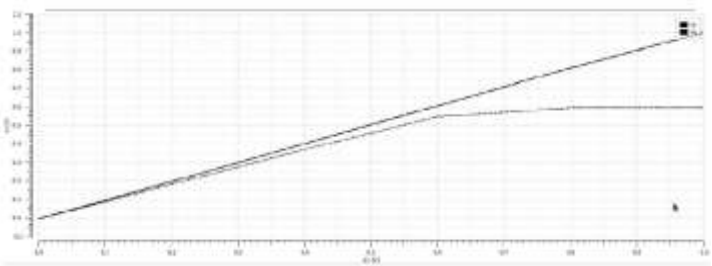

Fig.6 Vx=Vy

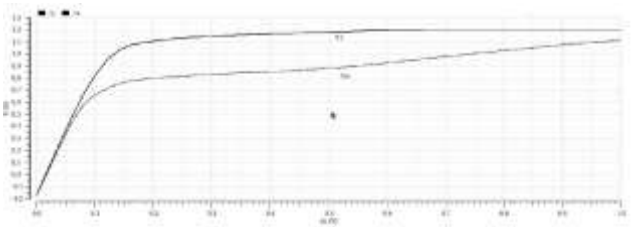

Fig.7 Vz=Vw

V. Conclusion

A full wave current rectifier is presented, which is mainly build to work in current mode circuits where the input to the circuits are in current form and also processed in the current form. This type of rectifiers can be used in envelope detectors or in AM modulation demodulation circuits. In RF detectors, working in current mode only, this rectifier will be very use full. We are also using this rectifier in our communication circuits which is working in current mode. This circuit shows the power consumption of almost 13uWatts for 10uA signals. The power consumption varies with respect to the value of the current signals. A new and improved design of CFOA is presented based on the second generation current conveyors and made on 180 nm CMOS technology. All the four equations are verified with DC and transient analysis. The proposed CFOA is suitable for low power, low supply and high bandwidth requirement applications. As the input impedance is very low almost 50W, circuit will not easily get loading effect. It requires further enhancement for high slew rate and gain improvements.

Vi. Future Work

We will use this circuit in our communication circuits i.e. in receiver only where we need to fetch the envelope of the current signal which is coming from the filters. Rectifier is efficient enough to get the output with minimum loss. We will also try to design it for higher frequency signals. We will further design the communication system, transmitter and receiver using this CFOA. And test it for voltage mode as well as for current mode signals.

References

[1]. A. Faheem, N. Bhagat, U.P. Khot. "Current Mode Full Wave Rectifier Topology for Integration".*In: 3rd IEEE International Conferenceon Recent Trends in Electronics, Information Communication Technology (RTEICT-2018);* 2018.

[2]. A. Faheem, N. Bhagat, U.P. Khot. "Design of low voltage supply Current Feedback Operational Amplifier". *In: 2nd International Conference on Inventive Communication and Computational Technologies (ICICCT 2018);* 2018.

[3]. RobertM. Cuzner,GiriVenkataramanan, ”Current Source Rectifiers Con- duction Modes of operation”. *IEEE Transactions on Industry Applications*, 51(1).2014 7.

[4]. Mehmet Sagbas, ShahramMinaei, UmutEnginAyten, ”Component reduced current-mode full-wave rectifier circuits using single active component”. *IET Circuits, Devices Systems*, 10(1). 2016 1.

[5]. ZhenhuaWang, ”Full-Wave Performed Suitable Precision Rectification that is in Current Domain and Very for CMOS Implementation”. *IEEE Transactions on*, 39(6).1992 6.

[6]. N.A. Bhagat, U.P. Khot. "Current Mode based Communication System". *In: International Journal of innovative research in electrical electronics instrumentation and control engineering. vol. 3; 2015.* p. 1–8.

[7]. SudhanshuMaheshwari, ”Current Controlled Precision Rectifier Circuits”. *Journal of Circuits, Systems, and Computers*, 16(1). 2007.

[8]. Cheng-Chieh Chang and Shen-Iuan Liu, ”Current mode full wave Rectifier and vector summation circuit”. *Electronics Letters*, 36(19).2000, 14.

[9]. C. Popa. *CMOS Computational Circuits with Improved Performances;* 2013.

[10]. N.H..J. Koton, K. Vrba. *Current-Mode Precision Full-Wave Rectifier Using Two WTACells;* 2011.

[11]. R. Djukic. *Full-Wave Current Conveyor Precision Rectifier.Serbian Journal of Electrical Engineering*, 5(2). 2008 11, 263–271.

[12]. U.P..T.S. Rathore. Khot,"Voltage Mode-to-Current Mode Transformation". */nternational Journal of Engineering and Technology*, 4.2012, 5–349.

[13]. S.J..B.J. Maundy.Gift,"A New Design Topology for Low-Voltage CMOS Current Feedback Amplifiers"*JEEE TRANSACTIONS ONCIRCUITS AND SYSTEMSII.'. EXPRESS,* 53(1). 2006 1.

[14]. Shahram MINAEI, Erkan YUCE, ”New Squarer Circuits and a Current- Mode Full-Wave Rectifier Topology Suitable for Integration”.*Radio Engineering*, 19(4).2010 12.

[15]. H. Ghallab, W. Badawy. Senior Member, "A New Topology for a Current-Mode Wheatstone Bridge". vol. 53; 2006.