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VOLUME 1
- Circuits and Systems
- Control Engineering
- Electrical Power Engineering
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VOLUME 2
- Communication Systems
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TPM2-7-4  
4:20 PM  
The Improvement a New Method for a Front-End of Military Vehicles Sound Recognition Using EHMM  
Yingyot Sa-nguanpuag1, Panuthat Boonpramuk2  
1Graduate school of Electrical engineering, King Mongkut’s University of Technology Thonburi, Bangkok, Thailand  
2Innovation and Control System Engineering Department, King Mongkut’s University of Technology Thonburi, Bangkok, Thailand

TPM2-7-5  
4:40 PM  
Precise Phone Boundary Detection using Selective Context-dependent Acoustic Refinement  
Sirinoot Boonsuk, Proadpran Punyabukkana, Atiwong Suchato  
Department of Computer Engineering, Faculty of Engineering, Chulalongkorn University, Bangkok, Thailand

8:30 AM - 9:50 AM  
Session FAM1-6  
Friday, 11 May 2007  
Digital Signal Processing I  
Chairperson: Tanee Demeechai, Mahanakorn University of Technology

FAM1-6-1  
8:30 AM  
Novel Precision Current-mode Full-wave Rectifier and Class B Push-Pull Current Amplifier Using BiCMOS Current-controlled Current Conveyors  
Winai Jaikla1, Montree Siripruchyanun2  
1Electric and Electronic Program, Faculty of Industrial Technology, Suan Sunandha Rajabhat University, Bangkok, Thailand  
2Department of Teacher Training in Electrical Engineering, Faculty of Technical Education, King Mongkut’s Institute of Technology North Bangkok, Bangkok, Thailand

FAM1-6-2  
8:50 AM  
Optical Diffraction-Based Object Dimensions Measurement in Reflection and Transmission Modes  
Sarun Sumriddetchkajorn, Kosom Chaitavon  
Photonics Technology Laboratory, National Electronics and Computer Technology Center, Pathumthani, Thailand

FAM1-6-3  
9:10 AM  
CCCDTAs-based Versatile Quadrature Oscillator and Universal Biquad Filter  
Winai Jaikla1, Montree Siripruchyanun2  
1Electric and Electronic Program, Faculty of Industrial Technology, Suan Sunandha Rajabhat University, Bangkok, Thailand  
2Department of Teacher Training in Electrical Engineering, Faculty of Technical Education, King Mongkut’s Institute of Technology North Bangkok, Bangkok, Thailand

FAM1-6-4  
9:30 AM  
A Study of Optical Phase Retardation and Absorption Measurement by using a Fiber Loop Mirror Architecture  
Kanitha Katanyukumanon1, Sarun Sumriddetchkajorn2, Toemsak Srihirin1  
1Department of Physics, Faculty of Science, Mahidol University, Bangkok, Thailand  
2Photonics Technology Laboratory, National Electronics and Computer Technology Center (NECTEC), National Science and Technology Development Agency (NSTDA), Pathumthani, Thailand
Novel Precision Current-mode Full-wave Rectifier and Class B Push-Pull Current Amplifier Using BiCMOS Current-controlled Current Conveyors

Winai Jaikla* and Montree Siripruchyanun**

*Electric and Electronic Program, Faculty of Industrial Technology, Suan Sunandha Rajabhat University, Dusit, Bangkok, 10300, THAILAND Email: jnai2004@yahoo.com
**Department of Teacher Training in Electrical Engineering, Faculty of Technical Education, King Mongkut’s Institute of Technology North Bangkok, Bangkok, 10800, THAILAND Email: mts@kmitnb.ac.th

Abstract- This article introduces a novel version for implementing current-mode precision full-wave rectifier and class B push-pull current amplifier. The features of the proposed circuits are that: it can rectify and amplify current signal with controllable output magnitude via an input bias current: the output current save ideally free from temperature variation. In addition, direction of the output current signals can be arbitrarily controlled by current in the circuits to be either positive or negative without changing circuit topology, which differs from the previous literatures. Circuit descriptions merely consist of 3 BiCMOS CCCIs. The performances of the proposed circuits are investigated through PSPICE. They show that the proposed circuits can function as a current-mode precision full-wave rectifier and push-pull current amplifier where input current range from -80μA to 80μA can be achieved at ±2.5V power supplies. The maximum power consumption is 1.43mW. In addition, the highest frequency is restricted at up to megahertz range.

Index Terms- full wave rectifier, BiCMOS, current-mode, class B, current amplifier, push-pull

I. INTRODUCTION

A precision rectifier is extensively used in signal processing circuits, for instance, in an AC to DC converter, in a signal polarity detector, in a peak signal detector, in an automatic gain control system [1-2]. Basically, a voltage-mode precision rectifier employs an operational amplifier and a diode [3]. The output signal confronts a zero-crossing distortion due to characteristic of the diode [4]. This problem has been subsequently solved by proposing the novel circuit without a diode [5]. In addition, the precision rectifiers are modified to use other active elements to achieve wider frequency response, for example, current conveyor [6] and current feedback operational amplifier [7].

Since a low-voltage operating circuit becomes necessary as in portable and battery-powered equipment, the current-mode technique is ideally suited for this purpose more than the voltage-mode one. Presently, there is a growing interest in synthesizing the current-mode circuits because of more their potential advantages such as larger dynamic range, higher signal bandwidth, greater linearity, simpler circuitry and lower power consumption [8-9]. From our investigations, there are seen that the previous literatures have proposed the current-mode precision rectifiers [10-12]. Unfortunately, the output magnitude of those proposed circuits can not be adjusted. Consequently, they require a proper amplifier to achieve appropriate level of output signal. Furthermore, in case of opposite polarity of output signal is required, it must be unavoidably changed the circuit topology or added a current inverter. This makes the circuit more complicated. Some of them employ a number of passive elements, which is not suitable for realizing into an integrated circuit [13]. The operations of all mentioned circuits, moreover, are dependent on temperature.

On the other hand, the current amplifiers find wide applications, particularly in a system that requires a low power supply voltage, such as in communication system, instrumentation system, biomedical system, etc. [14]. Recently several current amplifiers have been proposed, however, their current gain cannot be electronically and linearly be tuned [15]-[17]. Basically, class-A current amplifiers have linear characteristics. However, they require DC bias currents that restrict the allowable signal swing range and lead a high-power consumption. The DC power consumptions of class-A amplifiers do not depend on the signal amplitude but it is determined by the DC bias current and voltage of the power source. On the other hand, class-B amplifiers require no DC bias current, thus there is no power consumption when no signal is processed in the amplifiers. In addition, the DC power of the class-B amplifiers vary with the magnitude of the processing signal, thus quite good power efficiencies are expected.

The purpose of this paper is to introduce novel current-mode precision rectifier and class B push-pull current amplifier, whose output magnitude and polarity are electronically controllable without changing a circuit topology or adding any more circuit. They can be applied in an automatic control via a microprocessor. Each circuit construction consists of 3 CCCIs. The PSPICE simulation results are also shown. They confirm that the proposed circuits provide a wide range of input current, temperature-insensitive, wide range of frequencies. In addition, controllability of the output magnitude and polarity can be achieved via an input bias current and control current, respectively.
II. CIRCUIT PRINCIPLE

A. BiCMOS Current Controlled Current Conveyor (BiCMOS CCCII)

CCCII is a versatile analog building block which is similar to the conventional Current Conveyor (CCII) except that the CCCII has a finite input resistance \( R_X \) at the \( X \) terminal. CCCII has the advantage of electronic adjustability over the CCII, because it allows the adjustment of intrinsic resistance \( R_X \) via the bias current \( I_B \) as shown in the following equation.

\[
R_X = \frac{V_T}{2I_B}.
\]

Where \( V_T \) is the thermal voltage. The matrix-relationship between the voltage and current variables among port \( X \), \( Y \) and \( Z \) of an ideal CCCII can be described by the following matrix equation

\[
\begin{bmatrix}
   i_y \\
   v_y \\
   i_z
\end{bmatrix} =
\begin{bmatrix}
   0 & 0 & 0 \\
   1 & R_X & 0 \\
   0 & \pm 1 & 0
\end{bmatrix}
\begin{bmatrix}
   v_x \\
   i_x
\end{bmatrix}.
\]

Where the positive and negative signs of the current \( i_z \) denote the positive (CCCII+) and negative type (CCCII-), respectively. The symbol and the equivalent circuit of the CCCII+ are illustrated in Fig.1.

![Figure 1. CCCII (a) symbol (b) equivalent circuit](image)

B. The proposed current-mode rectifier circuit

Fig. 2 displays the proposed current-mode rectifier circuit. Considering the circuit in Fig. 2 and using the CCCII properties described in section A, we will receive

\[
i_{s2} = \begin{cases} 
\frac{I_{com}}{2I_B} I_m & \text{if } I_m > 0 \\
0 & \text{if } I_m < 0
\end{cases},
\]

(3)

and

\[
i_s = i_{s2} + i_{s3} = \frac{I_{com}}{2I_B} I_m.
\]

(5)

It can be seen from Eq. (5) that the circuit in Fig. 2 can perform as a precision current-mode full-wave rectifier whose output magnitude can be controlled via controlled current \( I_{com} \) or \( I_B \) and is theoretically temperature independent.

C. The proposed class B push-pull current amplifier circuit

Fig. 3 shows the proposed class B push-pull current amplifier. Considering the circuit in Fig. 3 and using the CCCII properties described in section A, we will receive

\[
i_{s2} = \begin{cases} 
\frac{I_{com}}{2I_B} I_m & \text{if } I_m > 0 \\
0 & \text{if } I_m < 0
\end{cases},
\]

(6)

\[
i_{s3} = \begin{cases} 
-\frac{I_{com}}{2I_B} I_m & \text{if } I_m < 0
\end{cases},
\]

(7)

and

\[
i_s = i_{s2} + i_{s3} = \frac{I_{com}}{2I_B} I_m.
\]

(8)

It can be seen from Eq. (8) that the circuit in Fig.3 can perform as class B push-pull current amplifier whose current gain can be controlled via control current \( I_{com} \) or \( I_B \) and which is temperature independent.

![Figure 2. Proposed current-mode full-wave circuit](image)

![Figure 4. Internal construction of BiCMOS CCCII](image)

III. SIMULATION RESULTS

To prove the performances of the proposed circuits, the PSPICE simulation program was used for the examinations. The PNP and NPN transistors employed in the proposed circuit were simulated by using the parameters of the PR200N and NR200N bipolar transistors of ALA400 transistor array from
The PMOS and NMOS transistors were simulated using the parameters of a 0.35μm TSMC CMOS technology [19]. The aspect transistor ratios (W/L) of PMOS and NMOS are 55/2.4μm and 12/2.4μm, respectively. The circuit was biased with ±1.5V supply voltages. Fig. 4 displays the internal construction of the CCCII used in the proposed circuit. Fig. 5 shows DC transfer characteristics of proposed rectifier, where $I_{B1}=50μA$ and $I_{in}=100μA$. It can be seen that the proposed circuit can provide a wide range of input currents and that the polarity of the output current can easily be changed by the change of polarity of the control current $I_{in}$. Fig. 6 shows the output current versus temperature variations at 27°C, 50°C, and 100°C. It is clearly observed that the output current is almost not dependent on the temperature variations due to internal temperature compensation in the CCCIIs used in the circuit, as explained earlier.

The output current responses with various input frequencies are also shown in Fig. 7. They confirm that the proposed circuit can rectify when frequency is up to megahertz range without disturbing magnitude of the output current. Fig. 8 displays the output currents as a function of the control current $I_{in}$ while $I_{in}=50μA$. These figures prove that the magnitude of the output current can easily be controlled electronically in accordance with the theoretical anticipations.

The proposed controllable gain class B push-pull current amplifier in Fig. 3 was tested by setting $I_{in}=40μA$ and $f=1kHz$, the results obtained are shown in Fig. 9. Fig. 10 shows the current transfer characteristic of the proposed current amplifier circuit. Fig. 11 represents plots of the current gain $A_{i}=I_{out}/I_{in}$ versus the control current. Fig. 12 shows the output current relative to temperature variations at 27°C, 50°C and 100°C. Fig. 13 insists that the proposed circuit can also amplify current signal when frequency is up to megahertz range. Slight cross over distortion at high frequency stems from the parasitic elements in the CCCIIs.
They show that the proposed circuits can function as a current-mode precision full-wave rectifier and class B push-pull current amplifier where input current range from -80μA to 80μA can be achieved at ±2.5V power supplies. The maximum power consumption is 1.43mW. Furthermore, the highest frequency is restricted up to megahertz range. With claimed outstanding features, it is very appropriate to further develop the proposed circuits to be part of a monolithic chip for working in a current-mode signal processing.

REFERENCES


IV. CONCLUSIONS

The novel current-mode precision rectifier and push-pull current amplifier, based on BiCMOS CCCIIs, which can rectify and amplify an input current with electronic controllability of output magnitude, have been reported in this paper. In addition, direction of the output current signal can be arbitrarily controlled by current in the circuit to be either positive or negative without changing circuit topology, which differs from the previous literatures. Each circuit description merely consists of 3 CCCIIs. The performances of the proposed circuits have been also investigated through PSPICE.