

CURRENT-MODE CCII+ BASED OSCILLATOR CIRCUITS USING A CONVENTIONAL AND MODIFIED WIEN-BRIDGE WITH ALL CAPACITORS GROUNDED

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ABSTRACT:

The paper deals with a couple of circuits of current-mode sine-wave oscillators. Both circuits presented are implemented using positive second generation current conveyors (CCII+). The principle of the first one is based on a conventional Wien-bridge network. However, this implementation suffers from the use of a floating capacitor, which can be unacceptable in the case of integration on the chip. The above mentioned drawback is solved in the second variant by the slight modification of the Wien-bridge network, which consequently allows the use of all capacitors grounded. The modified circuit version was manufactured by mean of the so-called diamond transistors, which stand for CCII+ active building blocks. The circuit behavior has been experimentally verified and results measured are included in the paper.

Keywords: Diamond transistor, Wien-bridge oscillator, current-mode, current conveyor

1 INTRODUCTION

Sinusoidal oscillator is a basic and one of the most common applications in analog signal processing. A wide range of conceptions and various approaches in terms of principle and utilized active elements exist there. In case of current-mode (CM) oscillator a current conveyor (CC) is frequently employed as an active building block. For example in [1, 2] several oscillators are implemented using first generation current conveyors CCI. More often than CCIs a second generation current conveyors CCII_s (usually positive) are used in oscillator circuits [3-8]. A specific type of oscillator is a Wien-bridge oscillator (WBO). Two different WBOs using two CCII_s+ are reported in [6]. Except two CCII_s+ additional eight passive components are employed there. Another two papers [7, 8] are focused on CCII+ based WBOs too. All the WBOs published in [7] require for its function (or if you like for the explicit current output possibility) CCII+ with multiple Z-terminals. Oscillator circuits in [8] employed CCII+, but the output signal is available only in a form of voltage.

Except that, all the circuits published there contain one floating capacitor. The purpose of our paper is to propose another two more WBO realizations using two CCII⁺ and six passive components (four resistors and two capacitors).

The paper deals with two different WBO circuits. Both of them are based on so-called diamond transistors (DT) [9]. DT is a part of commercially available integrated circuit OPA860. DT with emitter (E), base (B) and collector (C) terminals stands for CCII⁺ with terminal X, Y and Z (Fig. 1) here. DTs were successfully employed in many applications before, in which more advanced active building blocks were implemented using them.



Fig. 1 Diamond transistor OPA860 as a CCII⁺

DTs were used e.g. in [10] for implementing ZC-CG-CDBA, or in [11] for implementation of CIBTA and then ZC-CITA in [12], FB-VDBA in [13, 14] and CIBDITA in [15]. A number of active elements and the methodology of their building by mean of DTs were published in [16]. DTs were also used as a part of VD-DIBA [17] a ZC-CG-CDBA [18].

2. PROPOSED CIRCUITS

The Fig. 2 shows proposed CM oscillator using two CCII⁺ and conventional Wien bridge network.

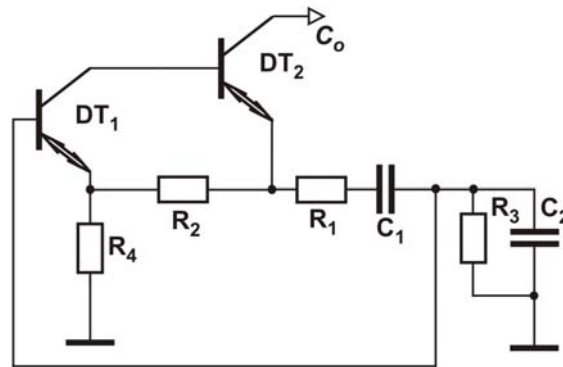


Fig. 2 CCII⁺ based wien-bridge oscillator

The potential drawback with this circuit is the floating capacitor C_1 , which can cause a problem in case of integration on a chip. Drawback mentioned is possible to overcome with the help of [19] and [20], where a way of derivation of Wien-bridge equivalent forms is described. A practical solution is achieved by the interchange of complete impedances of two branches, namely serial combination of R_1 and C_1 with R_4 . Resulting circuit is depicted in Fig. 3 and is perfectly suitable for chip integration, because all capacitors are grounded.

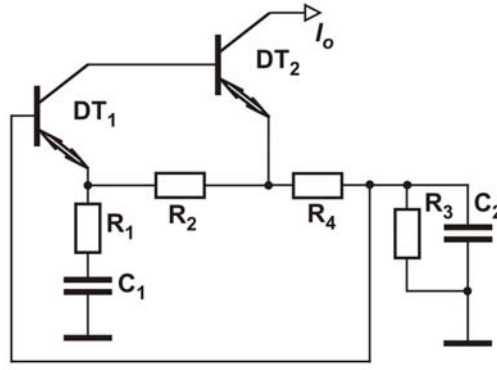


Fig. 3 Modified CCII+ based Wien bridge oscillator with all capacitors grounded

Characteristic equation (CE) has the same form for both variants (Fig. 2 and 3):

$$\text{CE: } s^2 C_1 C_2 R_1 R_3 R_4 + s(C_1 R_1 R_4 + C_2 R_3 R_4 - C_1 R_2 R_3) + R_4 = 0 \quad (1)$$

Oscillation condition (OC) and oscillation frequency (OF) consequently are:

$$\text{OC: } \frac{R_2}{R_4} \geq \frac{R_1}{R_3} + \frac{C_2}{C_1} \quad (2)$$

$$\text{OF: } \omega_0 = \frac{1}{\sqrt{C_1 C_2 R_1 R_3}} \quad (3)$$

Under the conditions, that $C_1=C_2=C$ and $R_1=R_3=R$, OC and OF can be simplified to the forms:

$$\text{OC: } \frac{R_2}{R_4} \geq 2 \quad (4)$$

$$\text{OF: } \omega_0 = \frac{1}{RC} \quad (5)$$

3. EXPERIMENTAL RESULTS

The modified WBO variant (Fig. 3) was chosen for experimental verification. Two DTs OPA860 were employed for circuit implementation. The following passive components values were used:

$C_1=C_2=1\text{nF}$, $R_1=R_3=100\text{R}$, $R_2=4\text{k}\Omega$ and $R_4=1\text{k}\Omega$
 $R_{\text{ADJ}}=330\text{R}$ and $R_b=100\text{R}$ in base terminal of each DT (see [9]);

According to (5), the corresponding theoretical f_0 value is 1.592MHz.

3.1 Amplitude stabilization

In order to perform relevant measurement, the manufactured WBO circuit was equipped by automatic amplitude stabilization circuit (Fig. 4). Such a circuit was implemented in a simple way by one optocoupler with internal photoresistor, one operational amplifier

and a few resistors. Internal photoresistor was connected in parallel to resistor R_2 , which directly influences an oscillation condition. Optocoupler LED diode was biased by the output signal amplified by conventional inverting amplifier (Fig. 4). Growing amplitude causes an increase of light emitting by the LED in optocoupler. That consequently decreases the value of photoresistor as well as its parallel combination with R_2 and results in the amplitude dumping and vice a versa. According to (4), the R_2 value should be a double resistance of R_4 . The fixed value of R_2 was intentionally chosen more than twice higher (4.3x as mentioned above), because this value with parallel photoresistor ensured steady-state oscillations. The optocoupler is a low-speed device, responding to the mean value of the signal rather than on its instantaneous values. Due to this feature, the circuitry for the amplitude control can be made up in such a simple way. However, for the same reason it is impossible to use the same stabilization circuit for very low frequency oscillators, because an optocoupler is able to react on an instantaneous value of the very low frequency signal.

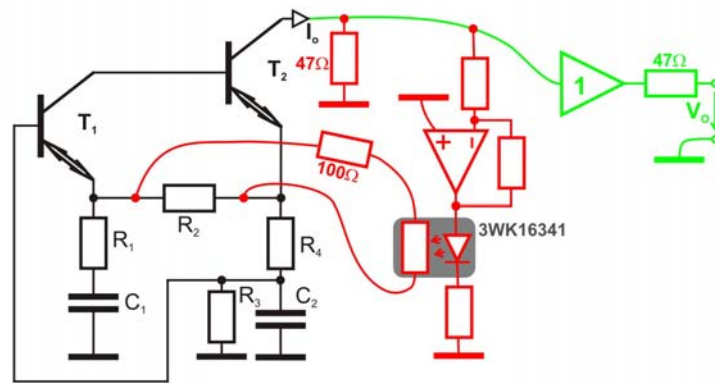


Fig. 4 Amplitude stabilization circuit and signal measuring

3.2 Results measured

The WBO output terminal (collector of DT_2) was enhanced by additional external resistor of 47Ω (Fig. 4). The current signal causes a voltage drop on this resistor, which can be consequently used for measuring as well as for amplitude control.

Voltage signal was connected via the voltage buffer and additional 47Ω matching resistor to oscilloscope/spectrum analyzer.

Fig. 5 shows the waveform generated.

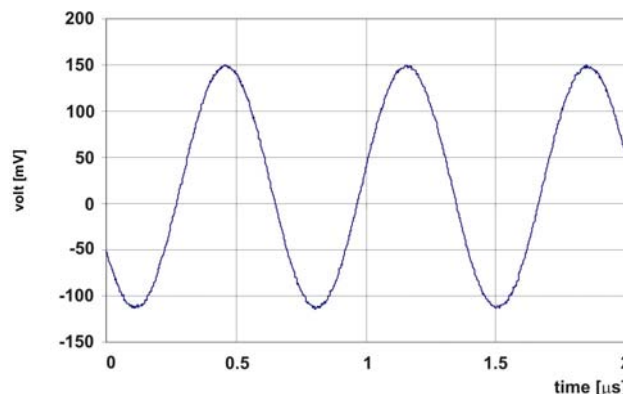


Fig. 5 The steady-state waveform of the voltage measured

The value of 100mV represents approximately 2mA of the output signal. Measured oscillation frequency was 1.433MHz, which is about 10% lower than expected theoretical value of 1.592MHz. THD measured was slightly better than 0.25%.

The analysis of real influences reveals two main reasons of difference between the measured and theoretical oscillation frequency. It is a parallel combination of parasitic capacitance and resistance of DT₁ collector terminal and base terminal of DT₂. According to [9], the concrete values are $C_Z=4\text{pF}$ ($C_Z=C_{C1}\parallel C_{B2}$) and R_Z only $48\text{k}\Omega$ ($R_Z=R_{C1}\parallel R_{B2}$).

THD measured is on a relatively acceptable level. However, the actual THD value primarily depends on the linearity of CCII_s+ used, linearity of amplitude stabilization element, and on ratios of R_3/R_1 and C_2/C_1 as shown in [21]. Diamond transistor inherently is not a linear device. In order to attain sufficient linearity, an additional so-called degeneration resistor must be used [9, 10]. That is why the THD value achievable with a chip integrated WBO will be fully dependant on a particular solution.

4 CONCLUSION

Two different variants of Wien-bridge type oscillators using CCII_s+ were proposed in the paper. The way to overcome the drawback of floating capacitor was shown and experimentally tested on manufactured circuit. Positive second generation current conveyors CCII_s+ were implemented by means of the so-called diamond transistors OPA860. Experimental results described in Section 3 shows the 10% decrease of measured oscillation frequency comparing to its theoretical value. As a main factor causing this error seems to be a relatively low collector terminal resistance of diamond transistor used. To eliminate this real influence, a CCII+ with high output resistance should be designed.

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