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AN OTA-C OSCILLATOR DESIGN USING SIGNAL-FLOW GRAPHS

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SUMMARY :A linear sinusoidal oscillator is a network with a pair of imaginary-axis poles. Hence, when designing an oscillator aim is to place the poles of the denominator polynomial of the transfer function on the imaginary axis.

In this study an oscillator is designed using OTA's (operational transconductance amplifier) and grounded capacitors. Properties of signal-flow graphs are utilized in obtaining the design equations. The resultant active network is tested on computer successfully using a simulation software, PSpice, and waveforms are plotted.

ÖZET: Lineer bir sinüsoidal osilatör sanal eksen üzerinde bir çift kutbu olan bir devredir. Dolayısıyla osilatör tasarlarken amaç transfer fonksiyonun payda polinomunun köklerini sanal eksen üzerine yerleştirmektir.

Bu çalışmada OTA (geçiş iltekenliği kuvvetlendiricisi) ve topraklanmış kapasite elemanları kullanılarak lineer bir sinüsoidal osilatör tasarlanmıştır. Tasarım eşlitliklerini elde ederken işaret akış diyagramlarının özelliklerinden yararlanmıştır. Bulunan aktif devre PSpice simulasyon programıyla başarıyla test edilmiş ve dalga şekilleri çizilmiştir.

I.INTRODUCTION

Although currently a large majority of active networks are built with voltage-controlled voltage sources, it has become increasingly apparent that op-amp dependent networks have some important restrictions.Apart from their frequency-dependent behavior, no suitable method has been found to integrate an op-amp RC network with other analog or digital circuitry on the same chip.
In recent years OTA-C networks are receiving much attention because of their wide range of electronic tunability , high frequency applicability and integratibility in bipolar and CMOS technology

II.TRANSCONDUCTANCE AMPLIFIERS

The circuit symbol and the equivalent circuit of an ideal operational transconductance amplifier is shown Figure.1,(1).

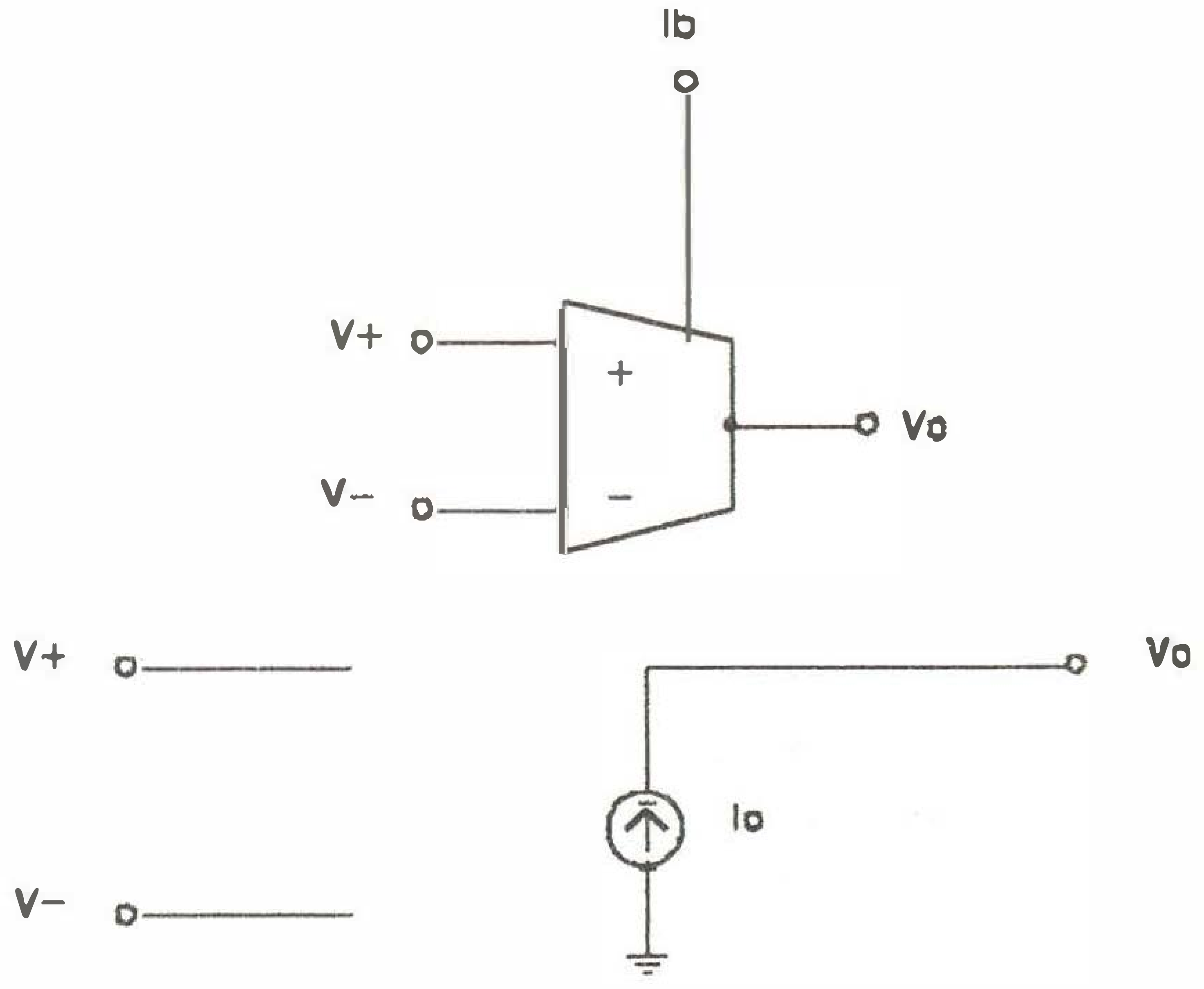

Figure.1a)circuit symbol b)small-signal equivalent circuit of an ideal OTA

As seen from Figure.1 an ideal OTA is a voltage-controlled current source, described by

$$I_o=g_m(V^+-V^-) \qquad (1)$$

whose both input and output impedance's are infinite.In many designs, the transconductance g_m is variable by setting a control bias current I_b so that g_m is proportional to I_b or $g_m=k.I_b$.

III.CONVERSION OF A FILTER INTO AN OSCILLATOR

There are several methods adopted when designing oscillators(2).In this work we designed an OTA-C oscillator by converting a second order low-pass filter using the properties of signal flow graphs(3).In Figure.3 a second order lowpass transfer function is shown along with a signal-flow graph realizing it.

$$\frac{V_0(s)}{V_i(s)}=\frac{a_0}{s^2+b_1s+b_0} \qquad (2)$$

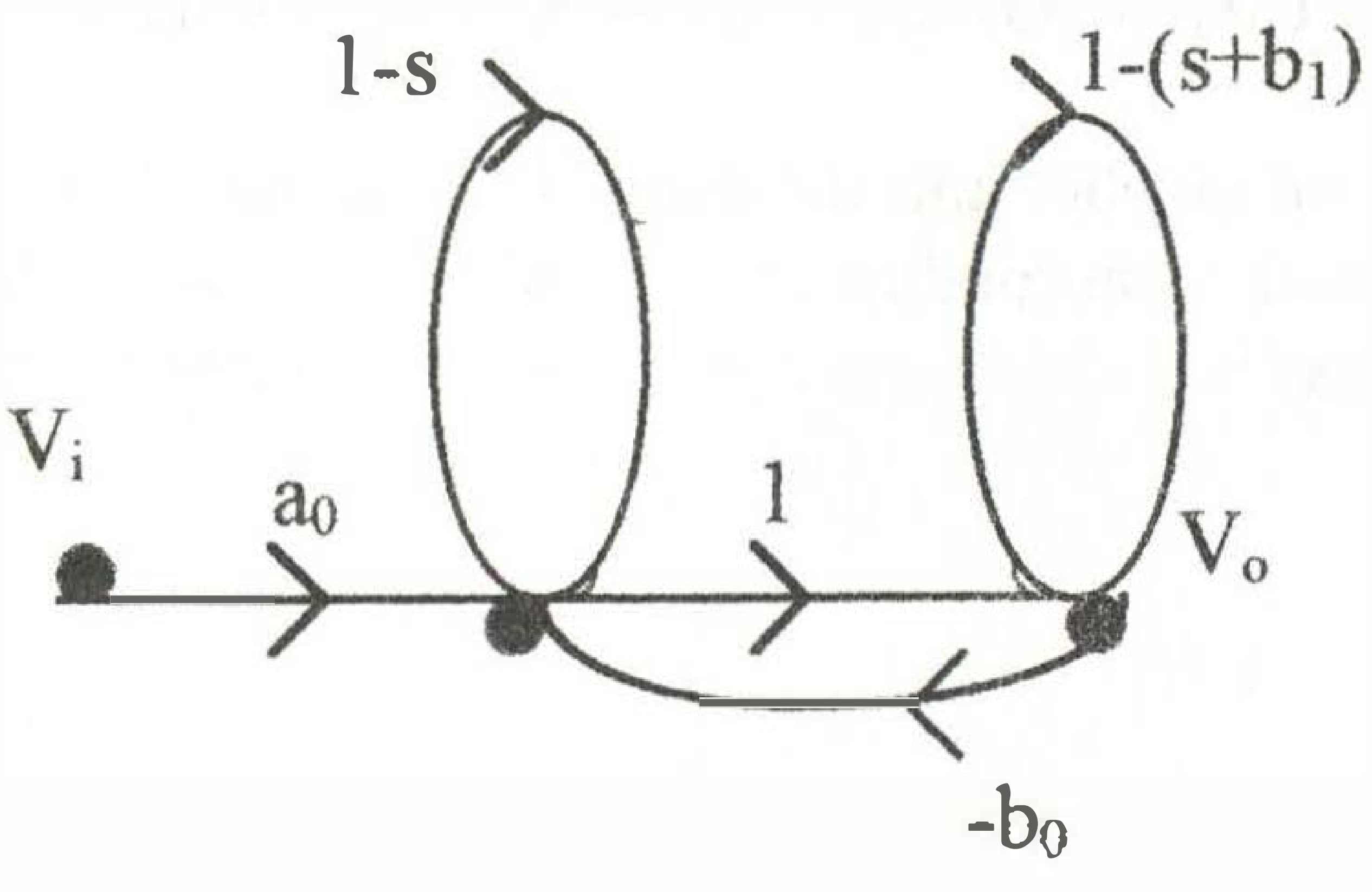

Figure.2-A signal flow graph for a general second order low-pass transfer function

On the other hand, a linear sinusoidal oscillator is a network with a pair of imaginary-axis poles.Hence, aim is to place the poles of the denominator polynomial of the transfer function on the imaginary axis, which requires the coffient b_1 becomes zero,

$$\frac{V_0(s)}{V_i(s)}=\frac{a_0}{s^2+b_0} \qquad (3)$$

Now, the sub-graphs of the graph in Figure.3 can be realized as in Figure.4-a, thus yielding the oscillator network shown in Figure.4-b, when the input was grounded.

Now, we have

$$V_0(s).\left(s^2+\frac{g_{m1}\cdot g_{m2}}{C_1.C_2}\right)=0 \qquad (4)$$

where oscillator frequency is given by

$$\Omega_0=\sqrt{\frac{g_{m1}\cdot g_{m2}}{C_1.C_2}} \qquad (5)$$

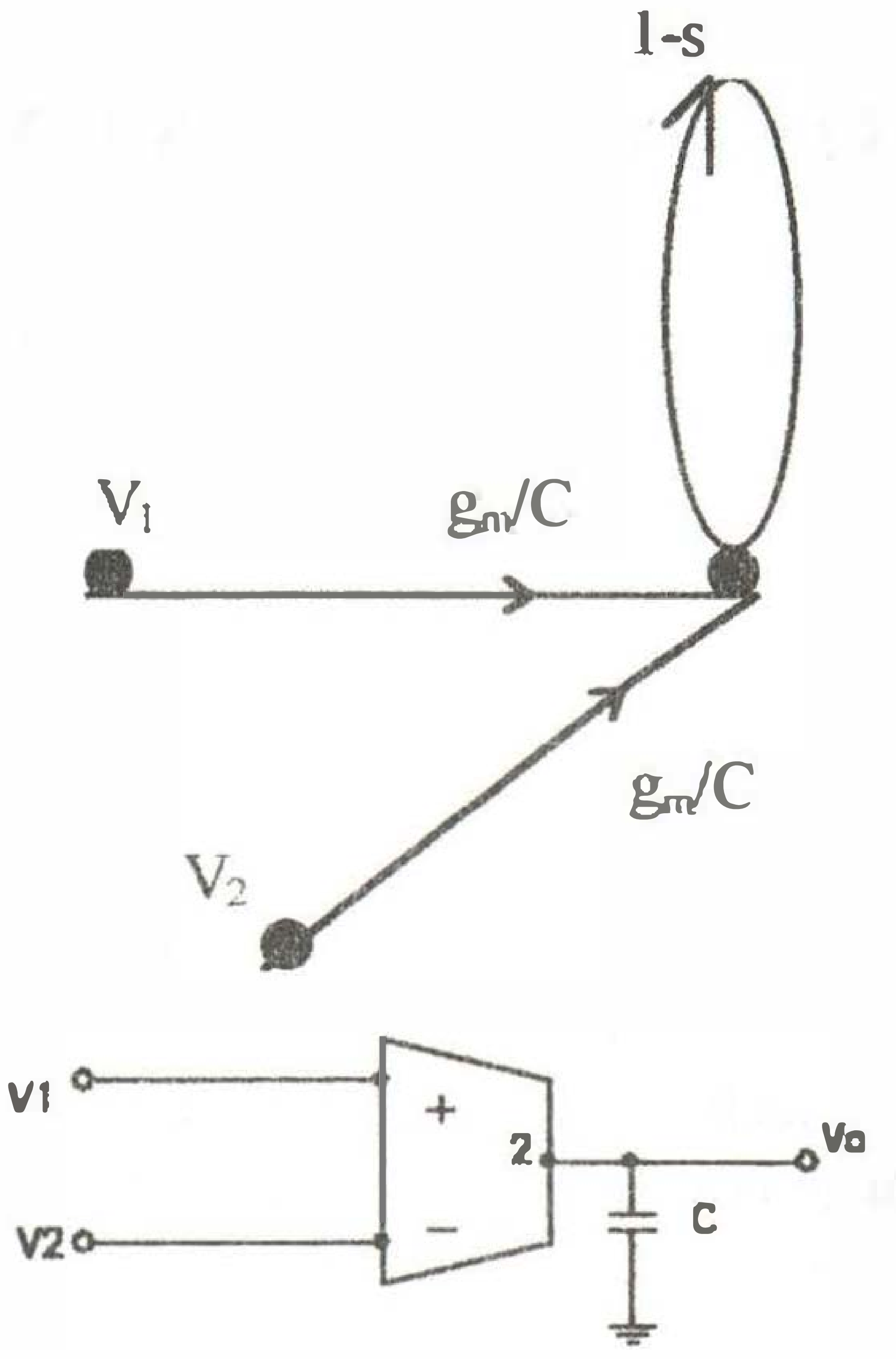

Figure.3-A sub graph representing the self loops of the graph in figure 3 with its OTA-C imlementation

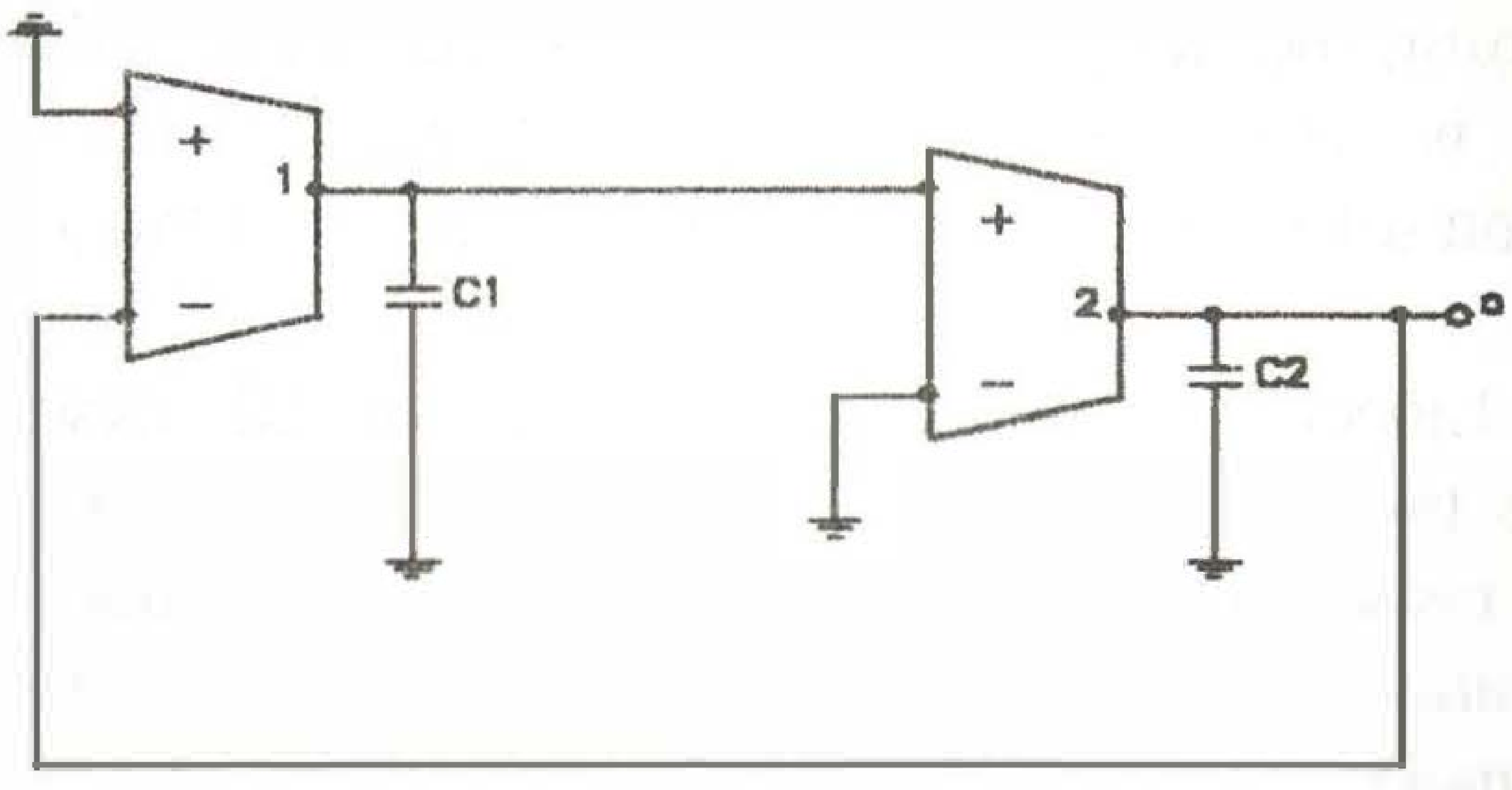

Figure.4-The proposed oscillator structure

IV.SIMULATION RESULTS

The oscillator circuit is simulated by using SPICE circuit analysis software program Figure.5 shows simulation result of the proposed oscillator structure, where

C_1=100pF

C_2=100pF

g_{m1}=1(mA/V)

g_{m2}=1(mA/V)

Using equation(5) we can calculate oscillation frequency which is

w_o=1.59MHz

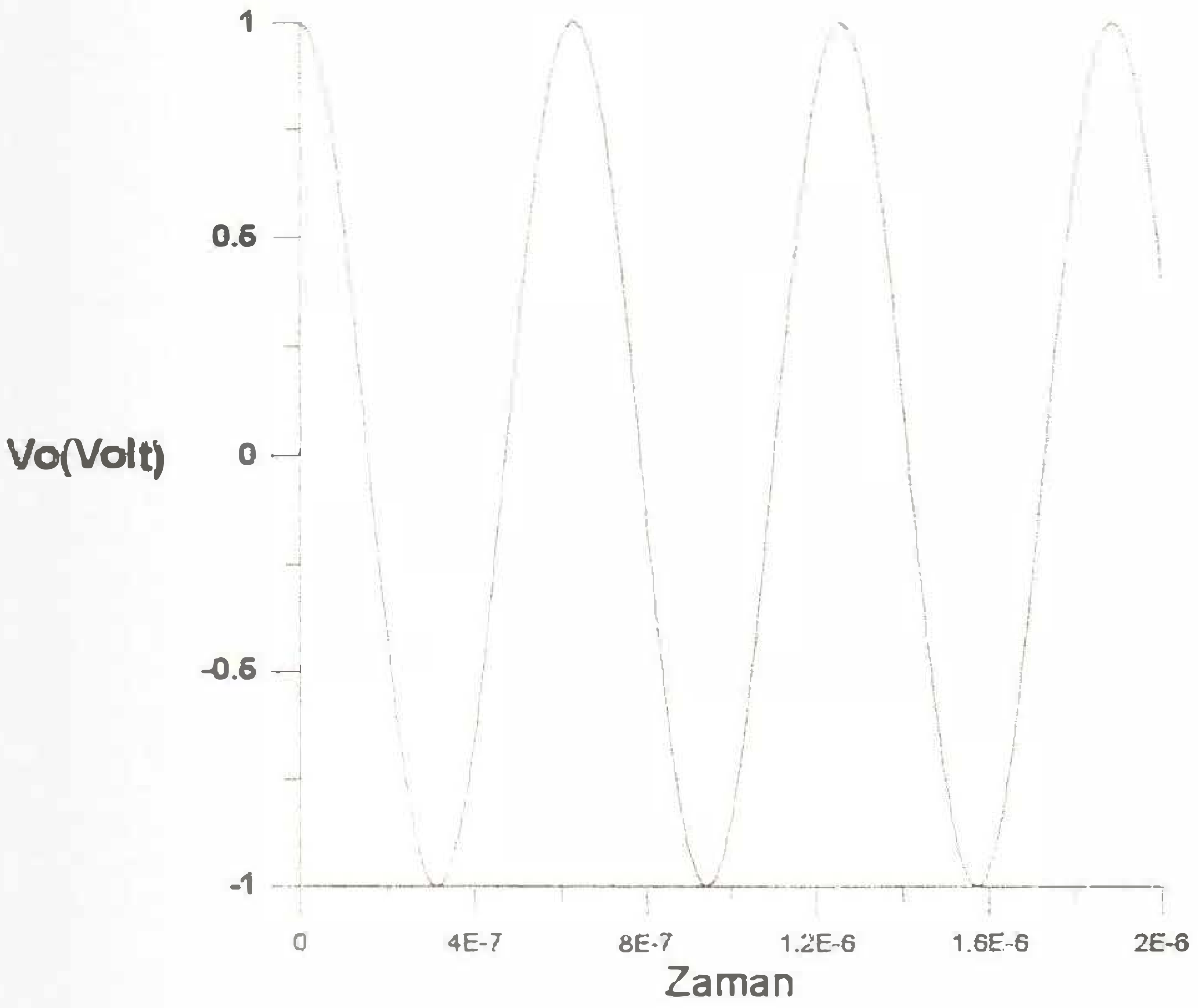

Figure.5- Output voltage waveform of proposed oscillator circuit

5.CONCLUSION

In this study a new active OTA-C oscillator network is obtained using signal-flow graph techniques and it is analized with an ideal OTA model where nonidealities of the OTA is not taken into account.Calculated oscilation frequecy is 1.59MHz which is very close to simulation frequency(1.56MHz)

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