Design of a Five Phase CMOS OTA oscillator

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***Abstract*— This paper presents a five phase CMOS OTA oscillator. In this oscillator we are using the resistor as an OTA. Since all the OTA-based simulators exhibit wide range electronic tenability of their important circuit parameters and reliable high frequency performance. The multiphase sinusoidal oscillator has their wide application in communication, signal processing and power controllers. A basic scheme is used for realization of odd phase oscillators using OTA as the active device. These oscillators can provide "n" signals equal in amplitude as well as equally spaced in phase.**

***Keywords*— OTA, TANNER TOOL.**

I. INTRODUCTION

The sinusoidal oscillator realized with operational trans conductance amplifier (OTA),g_m-C technique provide highly linear electronic tenability and have more reliable high – frequency performance, than operational amplifier based oscillator. Moreover, the g_m-C sinusoidal oscillator circuits are suitable for integrated circuit implementation, both in bipolar and CMOS technologies. The quadrature oscillator is an important unit in many applications, in communication, signal processing and instrumentation systems.Using OTA, oscillators have greater advantages over op-amp based oscillators .An OTA is an amplifying unit with a current output(high output resistance) in contrast to the classical op-amp having a low output resistance (voltage source). OTA are used normally without external feedback.They have better high frequency capability thanop-anps. The output voltages is simply output current times load impedance. Since g_m can be varied the gain can be controlled by an external control voltage. The first commercially available integrated circuit units were produced by RCA in 1969 (before being acquired by General Electric), in the form of the CA3080, and they have been improved since that time. Although most units are constructed with bipolar transistors, field effect transistor units are also produced. The OTA is not as useful by itself in the vast majority of standard op-amp functions as the ordinary op-amp because its output is a current. One of its principal uses is in implementing electronically controlled applications such as variable frequency oscillators and filters and variable gain amplifier stages which are more difficult to implement with standard op-amps.Earlier versions of the OTA had neither the I_{bias} terminal shown in the diagram nor the diodes shown adjacent to it. They were all added in later versions. As depicted in the diagram, the anodes of the diodes are attached together and the cathode of one is attached to the non inverting input (Vin+) and the cathode of the other to the inverting input (Vin−). The diodes are biased at the anodes by a current (I_{bias}) that is injected into the I_{bias} terminal. These additions make two substantial improvements to the OTA. First, when used with input resistors, the diodes distort the differential input voltage to offset a significant amount of input stage non linearity at higher differential input voltages. According to National Semiconductor, the addition of these diodes increases the linearity of the input stage by a factor of 4. There are so many disadvantages of op-amp oscillator in context to the OTA oscillator. First, its output of a *current* contrasts to that of standard operational amplifier whose output is a *voltage*. Second, except for its input stage (which is a simple two transistor differential amplifier), its internal circuitry is completely different. The OTA is constructed completely of transistors and diodes; it uses no resistors or capacitors. Third, it is usually used "open-loop"; without negative feedback in linear applications. This is possible because the magnitude of the resistance attached to its output controls its output voltage. Therefore a resistance can be chosen that keeps the output from going into saturation, even with high differential input voltages.

II. PRINCIPLE OF OPERATION

Oscillation results from an unstable state; i.e., the feed-back system can't find a stable state because its transferfunction can't be satisfied.Any system can beunstable, when (1+Aβ) = 0, because A/0 is an undefined state. Thus, the key to designing an **oscillator** is to insure that Aβ = –1called the Barkhausen criterion.The –180°phase shiftcriterion applies to negative feedback systems,and 0° phase shift applies to positive feedback systems. The figure shown below shows the five phase CMOS OTA oscillator.

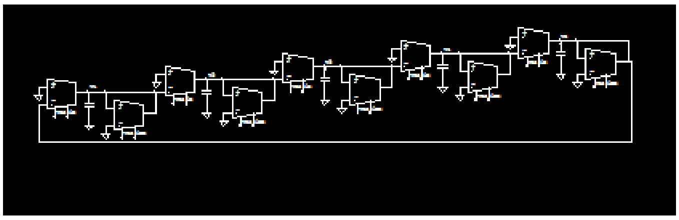

Fig.1.Schematic of five phaseCMOS OTA oscillator.

For the circuit given above, the voltage transfer function of each block is given by:

$$T(s)=\frac{-g_m/C}{S+1/RC}$$

For five phase,the analysis yields the condition and frequency of oscillation of multiphase sinusoidal oscillator given by:

$$\left[\frac{-g_m/C}{S+1/RC}\right]^5=1$$

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After expanding the expression, we get the result

$$\Rightarrow \frac{-g_m^5/C^5}{S^5+5s^5/RC+10S^3/R^2C^2+10S^2/R^3C^3+5S/R^4C^4+1/R^5C^5}=1$$

Put S=jω,we have:

$$\Rightarrow \frac{-g_m^5/C^5}{j\omega^5+5\omega^4/RC-j10\omega^3/R^2C^2-10\omega^2/R^3C^3+j5\omega/R^4C^4+1/R^5C^5}=1$$

Hence;

$$\frac{-g_m^5/C^5\left[\left[\frac{5\omega^4}{RC}-\frac{10\omega^2}{R^3C^3}+1/R^5C^5\right]-j\left[\omega^5-\frac{10\omega^3}{R^2C^2}+\frac{5\omega}{R^4C^4}\right]\right]}{\left[\frac{5\omega^4}{RC}-\frac{10\omega^2}{R^3C^3}+\frac{1}{R^5C^5}\right]^2+\left[\omega^5-\frac{10\omega^3}{R^2C^2}+5\omega/R^4C^4\right]^2}$$

=1 ……………… (1)

Equating Imaginary part to zero of equation no.(1),we get;

$$\omega^5-10\frac{\omega^3}{R^2C^2}+\frac{5\omega}{R^4C^4}=0$$

$$\Rightarrow \omega^4-\frac{10\omega^2}{R^2C^2}+\frac{5}{R^4C^4}=0$$

Letω^2=t, we have;

$$t^2-\frac{10t}{R^2C^2}+\frac{5}{R^4C^4}=0$$

After solving this equation, we get;

$$t=\frac{5\pm2\sqrt{5}}{R^2C^2};$$

Taking positive sign, we have;

$$t_1=\frac{9.472}{R^2C^2}$$

Taking negative sign, we have;

$$t_2=\frac{0.528}{R^2C^2}$$

Now equating the real part to one, we have;

$$\frac{10\frac{g_m^5\omega^2}{R^3C^8}-\frac{5g_m^5\omega^4}{RC^6}-\frac{g_m^5}{R^5C^{10}}}{\left[\frac{5\omega^4}{RC}-\frac{10\omega^2}{R^3C^3}+\frac{1}{R^5C^5}\right]+\left[\omega^5-\frac{10\omega^3}{R^2C^2}+5\omega/R^4C^4\right]^2}=1$$

Putting the value of $\omega^2=t_1=9.472/R^2C^2$, in the above equation, we get;

$$g_m^5=-354.873/R^5$$

This value is not acceptable.

Now putting the another value of $\omega^2=t_2=0.528/R^2C^2$, in the above equation, we get;

$$g_m^5=\frac{8.334}{2.887R^5};$$

Hence:

$$g_m=\frac{1.236}{R};$$

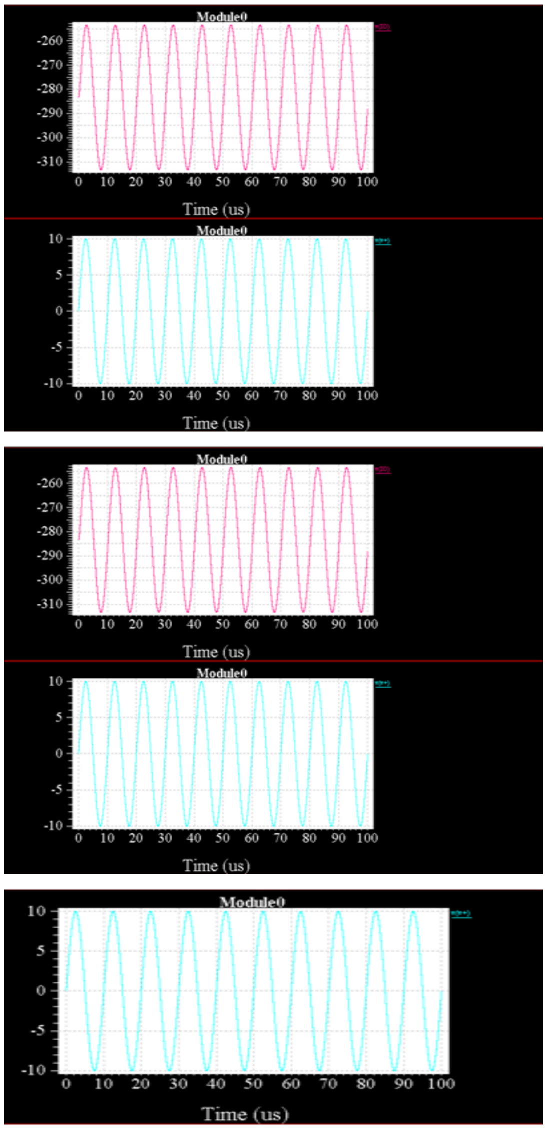
This value is acceptable.

And the value of ω corresponding to this g_m, is given by;

$$\omega=\frac{0.7266}{RC};$$

III. SIMULATION RESULTS

To prove the performances of the proposed circuit, the tanner tool was used for the examination. The entire five nodesgives sinusoidal waveform. Figure (1) depicts the schematic description of the CMOS OTA oscillator used in the simulations. The circuit was biased with -3V supply voltages.The results showed inbelow Figure 2 shows the oscillation frequency:



Figure(2).

Figure(2) shows the output of the oscillator. All nodes having the same sinusoidal output but having different phase. Hence from the above discussion we get our required condition of oscillation and frequency of oscillation.

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