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STUDYING THE I-V AND V-F CHARACTERISTICS OF A PHOTODETECTIVE STRUCTURE WITH OPPOSITELY ACTING POTENTIAL BARRIERS

The results of a study of the I-V and I-F characteristics of a semiconductor structure with oppositely acting potential barriers are presented. The relationship between I-V and I-F characteristics in the dark and in the light, as well as the relationship between the change in the sign of the photocurrent depending on the bias voltage at different wavelengths and the difference in the heights of potential barriers are revealed.

Keywords. optical signal, photodetector, double-barrier structure, radiation spectrum.

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THE OUTPUT NOISE REDUCTION OF RING VOLTAGE-CONTROLLED OSCILLATOR

A new method of reducing output noises in the ring voltage-controlled oscillator (VCO) is presented. In contrast to other methods, it keeps a small increase of area and saves accurate output frequency of the ring VCO. By using this method, the area of the circuit gets larger by 18%. By using the method, the noise error of the signal is 0% at the lowest frequency and 0.031% at the highest frequency.

Keywords: VCO, ring oscillator, inverter, current mirror, capacitor, resistor, noise.

1.Introduction. VCO is a very important block for mixed-signal integrated circuits and its accurate work is very required. The existence of noises is a big problem in mixed-signal circuits and there is often a need to reduce them by using some methodologies. The methodologies are different for different circuits, also one block may have many cases of methods for reducing the noises. The output noise usually occurs at high frequencies, because of the fast charge and discharge on capacitors or very big sizes of transistors. For example, in the DAC (digital-analog converter) or in ADC (analog-digital converter) output noises occur because of switching of many transistors at the same time, and it is one of the biggest problems in those converters. The noises in the circuit can make all the equipment nonfunctional, or it can simulate correctly, but has functional or performance problems. The example of noises on the periodic signal is shown in Fig.1.

Fig. 1. The periodic signal with noises at its switching moments (1-signal, 2-noises)

Here is presented a simple type of VCO based on the ring oscillator and a method of reducing the noises of the output signal in which the noises form mainly because of the parasitic capacitors at high frequency.

Literature review. There are several interesting methods of reducing output noises in mixed-signal circuits. Many methods are based on disguising the switching effect. For example, in [1] a method of reducing noises in the single chip with silicon substrate is described. The switching of digital schemes makes noise that is injected into the silicon substrate and that noise goes to the analog circuit and degrades the performance of the circuit. It has two solutions of reducing the noises. The first one works with reducing the switching noise generated in digital clock buffers. The second noise reduction method is based on reducing the switching noise below half of the clock frequency.

In [2], more internal circuits for noise reduction are used. The primary example is the switch on the inverter. Digital rise/fall transitions create wide-bandwidth noise. If we have a large number of gates in the circuit which receive a clock signal, the noise will be significant. For this, the noise reduction methods are also two. The first one requires multiple redesign efforts, as well as several trips to the wafer foundry. The redesign cost is sizable. The second method includes noise immunity in the original design.

Another method is described in [3]. In general, mixed-signal integrated circuits, noise coupling is often distributed with multiple talkers and listeners. The most effective methods of noise reduction include suppression of the talkers at the source. It is a ring VCO and a method of its noise reduction, for which capacitors and resistors must be used. The only disadvantage is making a bit larger area.

The problem with large capacitive coupling between the digital clock network and the substrate shared with the analog circuits and the solution of the problem is presented in [4]. It is possible to reduce the substrate noise in the analog circuit by increasing the distance to the digital circuit.

In [5], a set of techniques to reduce the switching noise generated by the digital circuitry based on classical digital methodologies at a circuit level is proposed. One of the most important sources of switching noise in large VLSI circuits is the clock-driven circuitry and the clock generation and distribution logic. Harmonics of clock signal are easily injected in the analog part.

In [6], a method of noise reduction in analog circuits is presented. Especially in mixed signal environments where digital circuits and analog circuits are combined, the noise generated by relatively noisy digital circuits often cause the analog circuits to produce incorrect output signals. Additional circuitry is added where one of the added circuits is denoted as the noise separator circuit.

In [7], noise reduction is developed by using passive filtering. Unfortunately, noise is a complex subject. While various online resources do cover this topic in detail, knowledge of the fundamental approaches to noise reduction can also be helpful. The inclusion of footprints for a feedback capacitor and isolation resistor to help fine-tune noise performance is covered.

2. The proposed ring VCO. The strategy of the method of the noise reduction for ring VCO is adding resistors and capacitors without changing the sizes of the transistors and saving the output frequency. The noise occurs because of rise/fall transitions. The primary circuit of ring VCO is shown in Fig.2. It consists of current mirrors and invertors.

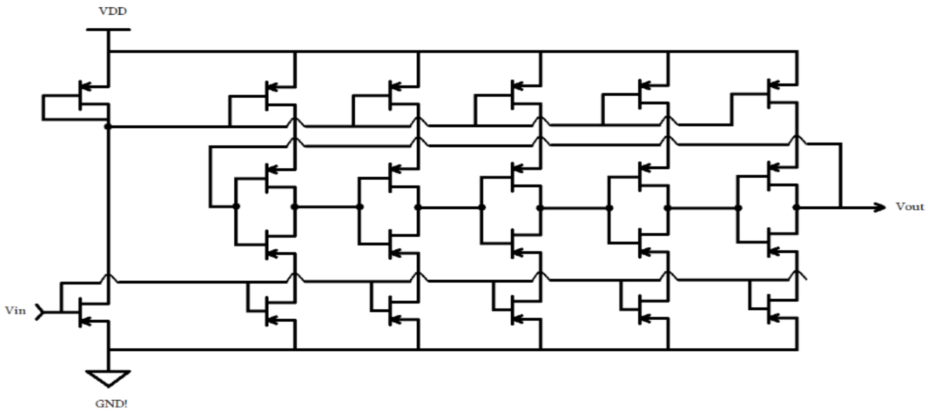

Fig. 2. The primary circuit of ring VCO

It is very difficult to reduce the noise saving the output frequency, because every inner change in the scheme leads to modification in the output signal. The modified transistor sizes, or the additional device changes the rise/fall times with some percent, by which the period of the output signal is also changed. To get a square output signal, it is necessary to add an inverter in the output, but it will also change the frequency. By this method the transistor sizes must not be changed, because the parasitic capacitance also changes with it, and it is difficult to calculate its effect on the output signal. So, we add a resistor and a capacitor on each inversing block of the VCO. The changed block is shown in Fig.3.

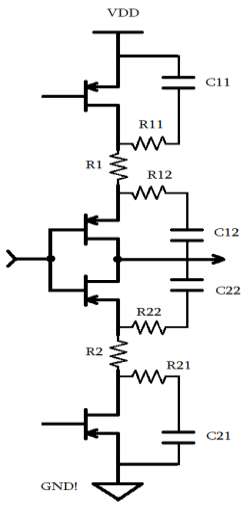

Fig. 3. The changed inversing block for the proposed VCO

C11, C12, C21 and C22 capacitors are used to keep longer rise and fall times to avoid from noises. R11, R12, R21 and R22 resistors are used with big resistance to avoid from the big impact of capacitors, which can distract the output signal from the right frequency. R1 and R2 are used with small resistance just to keep some voltage drop. With some percent it helps to avoid also from noises.

In the output of the circuit we need to use an inverter to make a square signal, but as it also affects the output frequency, the value of capacitors and resistors are taken into account also for that factor. All the proposed circuit is shown in Fig.4.

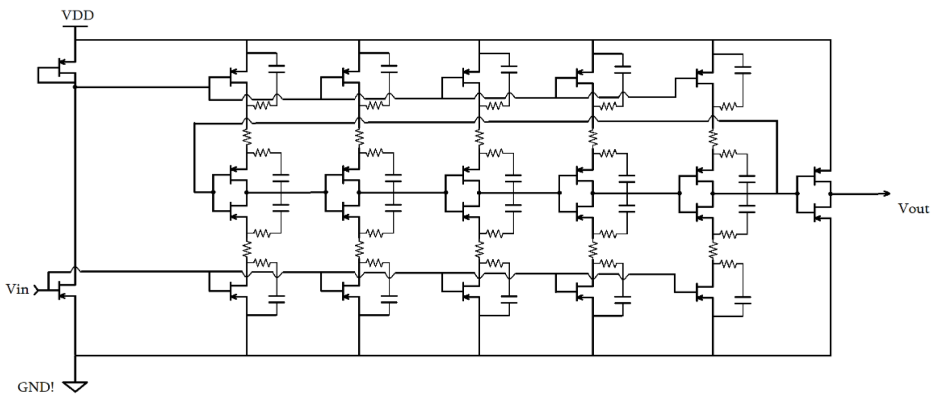

Fig. 4. The proposed ring VCO

3. Simulation results. The main block of VCO is designed. Simulations are performed using the HSPICE simulator [8] for a number of PVT corners including 3 main conditions (TT, FF and SS processes with respective voltage and temperature values) [8]. Here the results of TT typical corner are presented. The circuit is designed and simulation was performed in 32nm technology. The simulation results without using a method is shown in Fig.5. The signal gets higher than supply voltage (vdd).

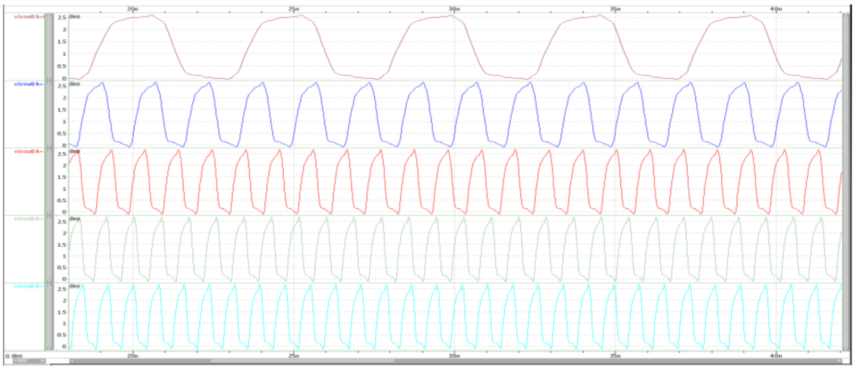

Fig. 5. Simulation results of the ring VCO without using the method

It is shown that the output signals had noises at the rise and fall times. The simulation results of the ring VCO by using the method is shown in Fig.6.

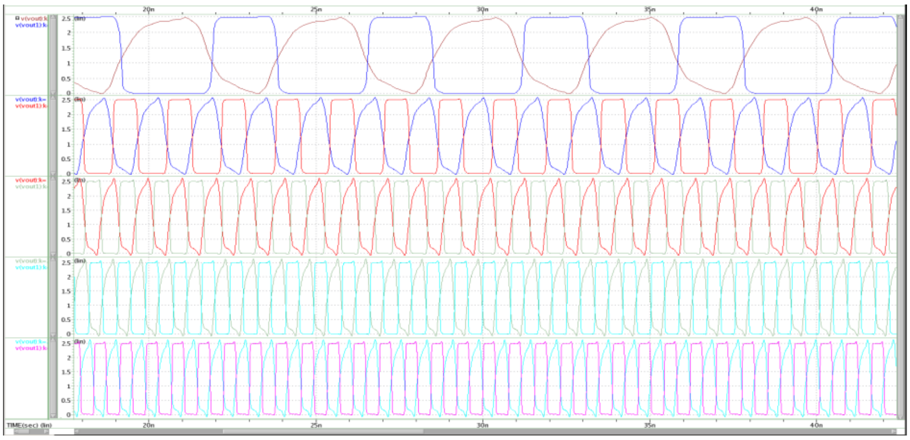

Fig. 6. Simulation results of the ring VCO by using the method. One signal is the input of the inverter used in the output of the ring VCO and the second one which is a square signal, is the output of the inverter

The output characteristics of the ring VCO without the method is shown in Fig. 7. The output characteristics by using the method are shown in Fig.8.

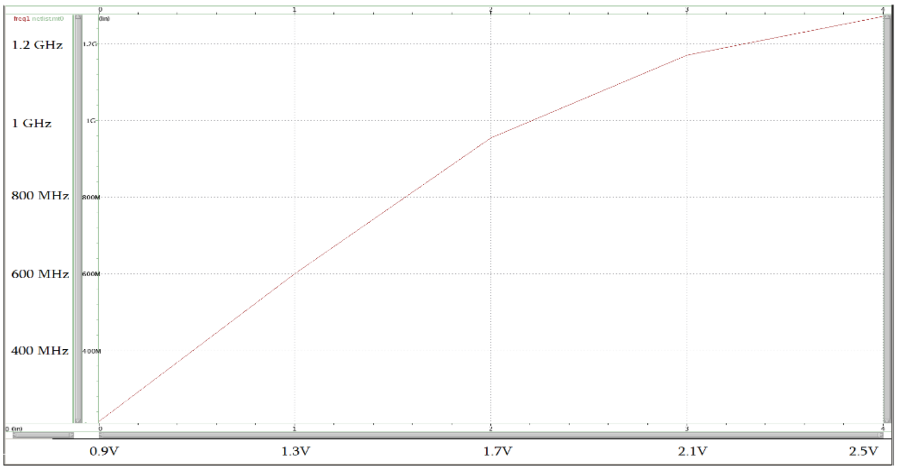

Fig. 7. The output characteristics of the ring VCO without using the method

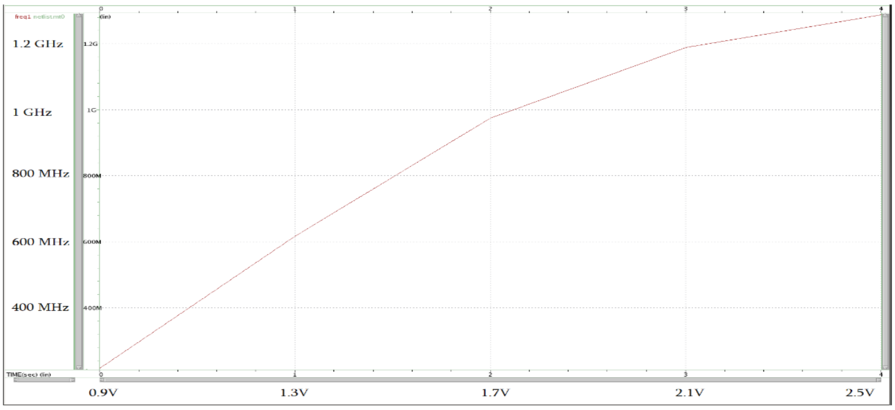

Fig. 8. The output characteristics of the ring VCO by using the method

Both characteristics are nearly the same with a very little difference (0.009%), so the linearity of the circuit isn't spoiled. The circuit designed in 32nm technology is shown in Fig.9. Without using the method, the noise error is 0.04% when the frequency of the circuit is 200 MHz and 0.085% when it is 1.22 GHz. By using the method, the noise error is 0% when the frequency is 200 MHz and 0.031% when it is 1.22 GHz. This shows that by using the method, the noise error gets a much smaller value. In the formula of the noise error, V_{ampl} is an amplitude of the output voltage, $V_{sup.volt}$ is a supply voltage.

$$error_{noise} = \frac{V_{ampl} - V_{sup.volt}}{V_{ampl}} * 100\%$$

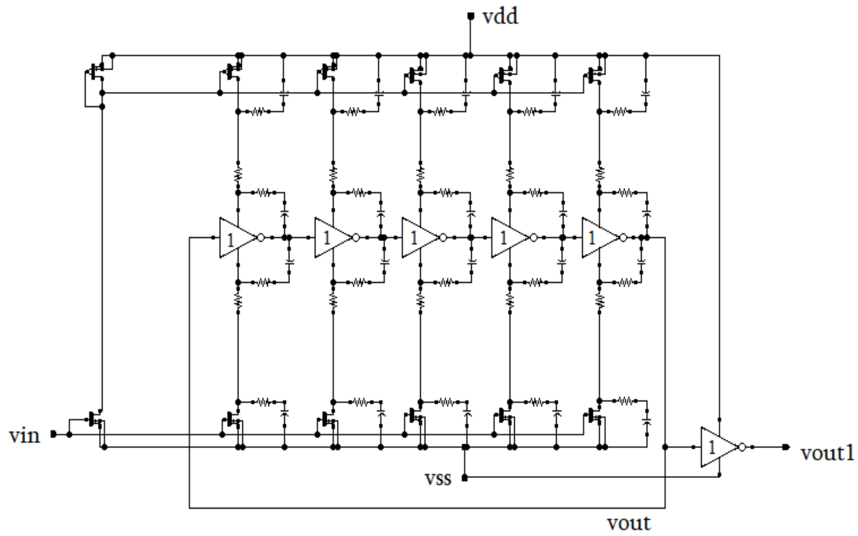

Fig. 9. The optimized ring VCO designed in 32nm technology (1-inverter)

Conclusion. A new method of noise reduction of the ring VCO is presented. As in the ring VCO the output signal occurs with self-generation, every additional device for reducing the noises can change the output characteristics. The main advantage of the method is that it reduces noise without changing any parameter of the design except the area. By using the method, the area of the circuit increases by 18%. Also, the output characteristics are changed by 0.009% by using the method in the ring VCO designed in 32nm technology. We save the parameters by nearly the same value, also not changing the sizes of the transistors and also by adding an inverter on the output for a square signal. The input voltage is changed from 0.9v to 2.5v, and the output frequency is changed from 200 MHz to 1.22 GHz. Without using a method, the noise error is 0.04% at 200 MHz and 0.085% at 1.22 GHz. By using the method, the noise error is 0% at 200 MHz and 0.031% at 1.22 GHz.

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ՕՂԱԿԱՎՈՐ ԼԱՐՈՒՄՈՎ ՂԵԿԱՎԱՐՎՈՂ ԳԵՆԵՐԱՏՈՐԻ ԵԼՔԱՅԻՆ ԱՂՄՈՒԿՆԵՐԻ ՆՎԱԶԱՐԿՈՒՄԸ

Ներկայացված է օղակավոր լարումով ղեկավարվող գեներատորի (ԼՂԳ) ելքային աղմուկների նվազեցման նոր մեթոդ: Ի տարբերություն այլ մեթոդների՝ այն ապահովում է մակերեսի փոքր աճը և ելքային ազդանշանի ճշգրտությունը: Մեթոդի կիրառմամբ սխեմայի մակերեսը մեծանում է 18%-ով: Մեթոդի օգտագործմամբ ազդանշանի աղմուկների սխալանքը 0% է ամենացածր հաճախության դեպքում և 0.031% է՝ ամենաբարձր հաճախության դեպքում:

Առանցքային բառեր. ԼՂԳ, օղակավոր գեներատոր, շրջիչ, հոսանքի հայելի, կոնդենսատոր, ռեզիստոր, աղմուկ:

А.А. БАБАДЖАНЯН

УМЕНЬШЕНИЕ ВЫХОДНЫХ ШУМОВ КОЛЬЦЕВОГО ГЕНЕРАТОРА, УПРАВЛЯЕМОГО НАПРЯЖЕНИЕМ

Представлен новый метод уменьшения выходных шумов кольцевого ГУН (генератор, управляемый напряжением). В отличие от других методов, при использовании данного метода создается малое повышение площади и сохраняется точность выходного сигнала, площадь схемы повышается на 18%, погрешность шумов выходного сигнала в случае низшей частоты составляет 0%, а в случае высшей частоты - 0,031%.

Ключевые слова: генератор, управляемый напряжением (ГУН), кольцевой генератор, инвертор, зеркало тока, конденсатор, резистор, шум.