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Modeling of 90nm Floating gate transistor (FGT) Ring Oscillator based VCO linearization model.

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Abstract.

FGT Ring Oscillators are non-volatile memory devices with a floating gate that can store charge, making them ideal for VCO applications. Ring oscillators, consisting of an odd number of inverters connected in a loop, have a frequency proportional to the delay through each inverter stage. However, achieving linearity in a ring oscillator can be challenging due to the inherent nonlinearity of transistors. The linearization model involves pre-conditioning the control voltage applied to the VCO to mitigate its nonlinearity. In this article, simulated an improvised approach to designing VCOs by utilizing Floating-Gate Transistors. Such non-traditional devices have special benefits including adjustable VCO threshold voltages and non-volatile memory attributes. Evidence for the potential for improved efficiency and adaptability of VCOs based on floating-gate transistors is presented in this paper.

Keywords: VCO, Ring Oscillator, Floating Gate

1. Introduction

In electronic circuits, voltage-controlled oscillators, or VCOs, are essential elements that are employed for timing, frequency synthesis, and signal modulation. The Floating Gate Ring Oscillator VCO is a customized form of VCO that utilizes certain characteristics of Floating Gate Transistors (FGTs) to enhance performance and adaptability. Considering transistors generally innately nonlinear, it can be challenging to accomplish linearity in a ring oscillator. Nevertheless, the oscillation frequency of a ring oscillator is proportional to the delay through each inverter step. By pre-conditioning the control voltage supplied to the VCO, the linearization model reduces the intrinsic nonlinearity of FGTs. Continuous control voltage modification has been rendered possible by a feedback mechanism, which also monitors the

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output frequency and makes adjustments in real-time to preserve linearity[1-5].

Traditionally, Voltage Controlled Oscillators (VCOs) have been designed using conventional transistor technologies like MOSFETs. However, achieving desired linearity, frequency stability, and frequency tunability in these VCOs can be complex due to the inherent nonlinearity of transistors and the challenges of controlling threshold voltages. Floating Gate Transistors (FGTs) offer a promising solution to these challenges by featuring an insulated floating gate within the transistor structure. This unique architecture allows FGTs to store electric charge on the floating gate, thereby altering the transistor's threshold voltage. This makes FGTs an ideal choice for voltage-controlled oscillators. The Floating Gate Ring Oscillator VCO[3] is a groundbreaking approach to VCO design, using FGTs to build oscillator stages in a ring oscillator topology. This allows better control over the threshold voltage and oscillation frequency, enhancing frequency tunability and improved linearity, addressing key challenges in traditional VCO design.

2. Design Method and Modelling

2.1. Overview of FGTs

Floating-Gate Transistors are a subset of non-volatile memory devices. It consist of a standard MOSFET structure with an additional insulated floating gate positioned between the control gate and the channel region. The presence of the floating gate allows for the storage of electric charge, which can be used to modify the transistor's threshold voltage[9]. The ring oscillator is an electronic circuit that generates a continuous wave output signal using an odd number of inverter stages connected in a ring configuration as shown in Fig1. Inverters are digital logic gates that produce an output opposite to their input.

The circuit works by creating a feedback loop, propagating a series of logic inversions, and determining the frequency of the output signal. Ring oscillators serve various purposes in electronic systems, including clock signal generation, frequency reference for phase-locked loops, delay generation, and oscillator testing and measurement in electronic design. They are simple and widely used in various electronic systems.

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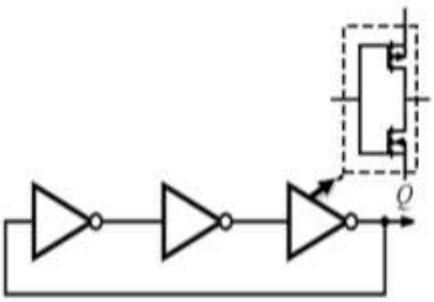

Fig1: Block Diagram of Ring Oscillator

2.2. Tunable Threshold Voltage and Non-Volatile Behavior

One of the key features of FGTs is their ability to store charge on the floating gate, effectively tuning the threshold voltage of the device. This property can be harnessed to create VCOs with a wide frequency tuning range. By adjusting the charge stored on the floating gate, the VCO's frequency can be varied over a significant range. FGTs are inherently non-volatile, meaning they retain their stored charge even when power is removed. This characteristic can be exploited for retaining oscillator frequency settings, making FGT-based VCOs suitable for applications where power efficiency and frequency stability are crucial[10-12].

2.3 Frequency Tuning of VCO Design Using Floating-Gate Transistors

To implement VCOs using FGTs, we propose a novel architecture that leverages the tunable threshold voltage and non-volatile behavior of these devices. The FGTs can be configured in a ring oscillator topology, where their threshold voltages are adjusted to control the oscillation frequency. The charge stored on the floating gate is the key parameter to control the oscillation frequency. By applying a variable control voltage to the FGTs, the threshold voltage can be modulated, leading to changes in the oscillation frequency. This provides a simple and efficient method for voltage-controlled frequency tuning.

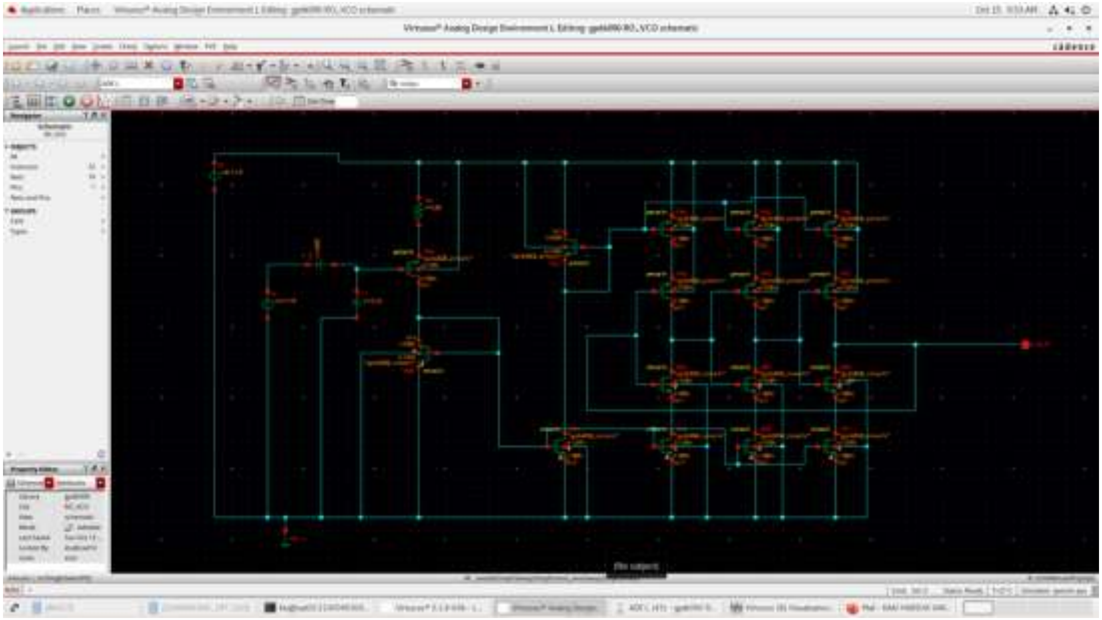

Fig 1: Design simulation of proposed method FGT-Ring Oscillator VCO**.**

3. Results and Discussion

VCOs were designed and tested at varying control voltages, demonstrating feasibility, and exhibiting a wide frequency tuning range and excellent frequency stability. To validate the proposed method of Linearization's of VCOs using FGTs. The FGTs were constructed using a standard CMOS cell, and the VCOs were designed and tested at varying control voltages.

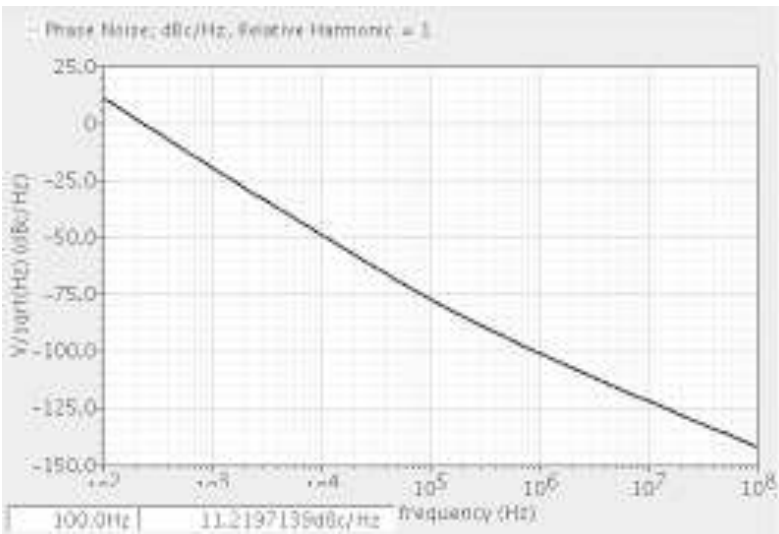

Fig 3: Simulation Graph results Phase noise in dBc/Hz

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The results demonstrated the feasibility of this approach, with the VCOs exhibiting a wide frequency tuning range and excellent frequency stability. The comparison shows VCO proposed shows better results in linearity.

Table 1: Comparison of results with literature

Parameter/Feature	**180nm VCO**	**90nm VCO (Proposed method)**
Frequency Range (GHz)	0.1 - 2 GHz	0.5 - 4 GHz
Power Consumption (mW)	10 - 50 mW	**5 - 18 mW**
Linearity (THD)	5% - 10%	**3% - 7%**
Frequency Stability (ppm/°C)	50 - 100	20 - 50
Phase Noise (dBc/Hz, 1 kHz)	-100 to -90 dBc/Hz	-110 to -95 dBc/Hz
Start-up Time (ns)	200 - 400 ns	**100 - 250 ns**
Silicon Area (mm²)	0.01 - 0.1 mm²	0.005 - 0.05 mm²

4. Conclusions

The integration of Floating-Gate Transistors into Voltage-Controlled Oscillators presents an exciting avenue for innovation in oscillator design. FGTs offer unique characteristics, such as tunable threshold voltage and non-volatile memory behavior, which can be harnessed to create VCOs with enhanced performance and versatility. The experimental results presented in this article support the feasibility of this approach and suggest its potential for widespread application in electronic systems. The future development of VCOs using FGTs promises to advance the field of oscillators and provide solutions for emerging technologies.

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