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OOK Transmitter in DG Finfet Technology

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ABSTRACT

In this paper we are going to use FinFET or double gate (DG) MOSFET instead of convention CMOS, to construct an OOK transmitter. Fundamental roadblocks in sustaining transistor miniaturization trends simply by reducing device length and other dimensions or using a more advanced material in building of device imply that more dramatic architectural changes are also needed; hence here we use the FinFET instead of CMOS. The advantage of FinFET over conventional CMOS is the ability to alter channel potential by more than one gate (e.g. double, triple, cylindrical) provided a relatively easier and more effective way to control the channel electrical and electrostatic characteristics, reducingthe short channel effects and leakage current considerably. In this project, we propose a power efficient double gate (DG) MOSFET based OOK transmitter in 32 NM DG FinFET technology. The proposed novel OOK (On Off Keying) modulator consist of only three DG MOSFET, making the circuit extremely power efficient. We will going to use ASU predictive technology model for 32 nm DG FinFETwith Synopsys HSPICE RF for the design and analysis of the DG MOSFET OOK transmitter [1].

Index Terms: CMOS (Complementary metal-oxide semiconductor), DG MOSFET (Dual gatemetal oxide semiconductor field effect transistor), OOK Modulation (On-off keying modulation),

I. INTRODUCTION

Scaling CMOS to and beyond the 22-nm technology node will most probably require the introduction of several advanced material and changes in the structure of the MOSFET to sustain required performance increases [1]. And because of it, in sub 22 nm scale MOSFETs build on silicon oninsulator with very thin channels and specifically engineered source/drain contacts will be replaced by 3D- designed multigate[2]-[3].As CMOS devices are becoming smaller and smaller to nanometer scale, causing increase in the short channel effects and variations in the process parameters which ultimately affect the reliability of the circuit as well as performance. To overcome these disadvantages of CMOS, FINFET is one of the promising and surely a better technology without sacrificing reliability and performance for its applications and the circuit designFinFETs have very good electrostatic control of the channel, meaning the channel can be completely switched off more easily. FinFETs boast a near-ideal sub-threshold behavior (associated with leakage), something that’s not easy to achieve in CMOS planar technology without considerable effort. FinFETs considerably reduces short channel effects. The short channel effects in CMOS planar technology are complex and have a significant impact on change in gate length and, because of this it also have significant effect on electrical and electronic performance. These advantages of CMOS technology can be useful for digital circuit design[4],[5], but for analog design properties of FinFET like the ability to handle GHZ modulation, and independent gate-drive mode make the multiple-gate MOSFETs an ideal choice also for analog radio frequency (RF) CMOS applications [6].

II. TRANSMITTER DESIGN

As shown in OOK transmitter block diagram, itconsists of OOK modulator, power amplifier, impedance matching network and antenna. Here to generate a 60 GHz carrier frequency we use VCO. The entire simulation for transmitter is performed for $V_{DD} = 1$ V

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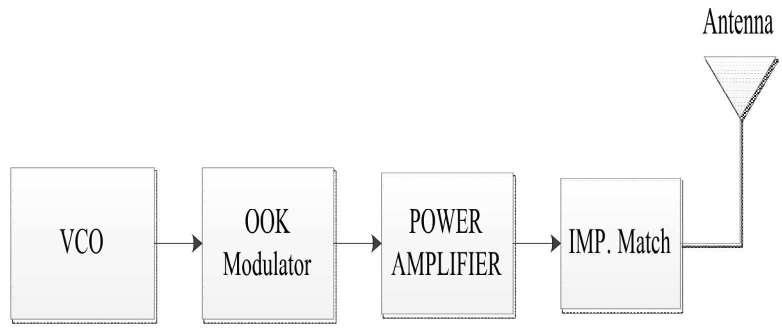

Figure 1: Block diagram of OOK transmitter

(A) VCO and Modulator

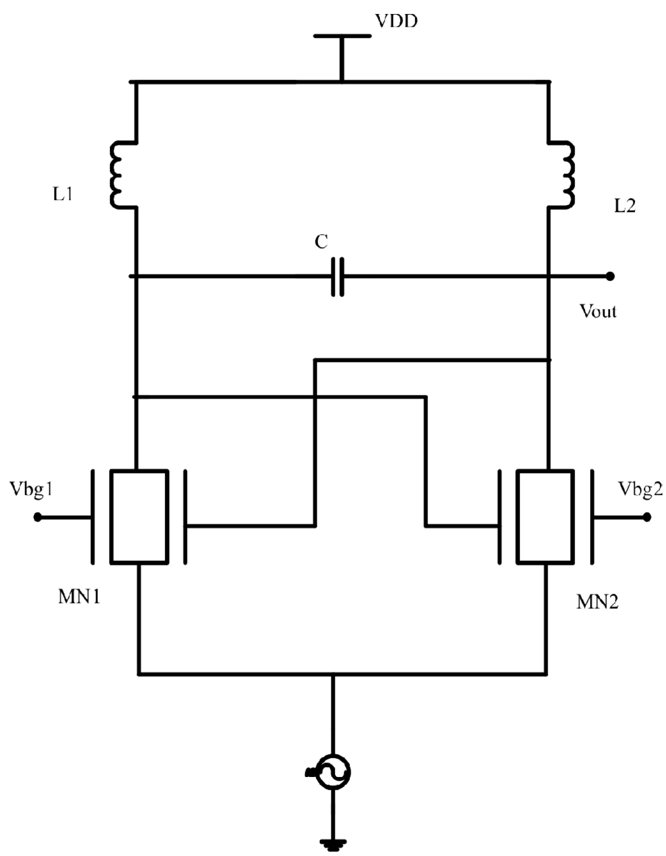

Figure 2: The circuit diagram of oscillator

Here we have using differential negative resistance oscillator for our design of the VCO. VCO can be tuned using back gate voltage [7]. The phase noise of the 60 GHz VCO is -133 dBc/Hz which is comparable to that of bulk CMOS.

Increasing demand for high data rates for growing number of users and applications has pushed the operating frequencies to millimeter-wave region these days. Especially, the 60-GHz band has been getting much attention for its wide unlicensed spectrum (5-GHz in common worldwide), which implies that Gbps communication is possible even with binary signaling. OOK modulation is one of the simplest form of binary signaling scheme, which transmits a carrier signal only when bit “1” is being sent. While being spectrally inefficient, employing OOK modulation greatly reduces the system complexity and power consumption since no complex phase locking/recovery and frequency conversion circuitries are required.

Since an OOK-modulated signal carries information solely by means of signal amplitude, any signal transmission during OFF state can significantly degrade the signal-to-noise ratio (SNR) at the receiver side. The SNR can be enhanced by increasing the transmitter's output power. This, however, leads to more DC power consumption. Alternately, the SNR can be increased by minimizing the leakage signal during OFF state while keeping the forward gain intact for the modulator, which effectively maximizes the ON/OFF isolation. A 60-GHz OOK modulator supporting up to 2.5-Gbps data rate with enhanced ON/OFF isolation.

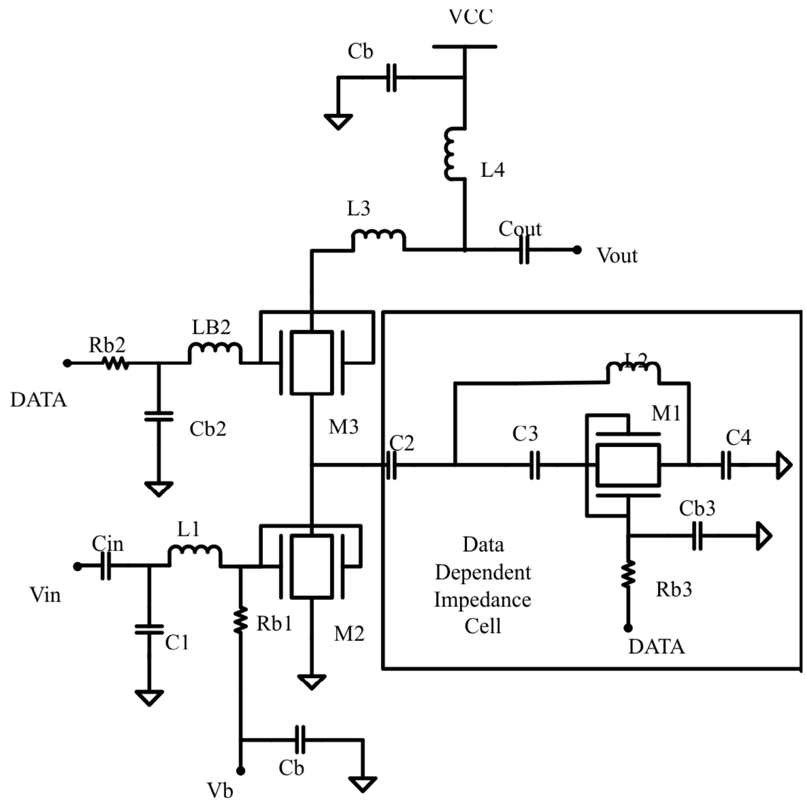

Figure 3: The circuit diagram of proposed OOK modulator.

The circuit schematic of the proposed 60-GHz OOK modulator, which is based on a single cascode amplifier stage, where the cascode device (M3) is turned ON and OFF according to the data sequence (i.e., 0 or 1.8 V). Data signal is applied to the base of M3 through RB2, which should be large enough to prevent overshoot in the events of data transition and small enough to have small RC time-constant (ô = RB2CB2) for high-speed data signal. A small inductor, LB2, is connected at the base of M3 in order to increase the forward gain as well as to provide an AC ground for the 60-GHz carrier signal by forming a series resonance with CB2. The proposed data dependent impedance cell is connected at node X and its impedance (ZE) at 60 GHz is designed to be high and low for ON and OFF states, respectively, for high-speed data signal.

One of the optimum solutions to can be implemented by adding a data-dependent impedance cell. When the data is 1.8 V, L2 and C3 with the on-resistance of M1 form a parallel resonance at 60 GHz, which is dominant over other series resonances. On the other hand, when the data is 0 V, a series resonance occurs at 60 GHz by C2, L2, and C4, while the parallel resonance formed by L2 and C3 with the offcapacitor of M1 is at far higher frequency than 60 GHz., the input impedance of the impedance cell is relatively high and very low at 60 GHz for DATA = 1.8 and 0 V, respectively. These results imply that, by employing the proposed impedance cell, improvement in the ON/OFF isolation can be expected while keeping the degradation in the forward gain negligible.

(B) Power Amplifier

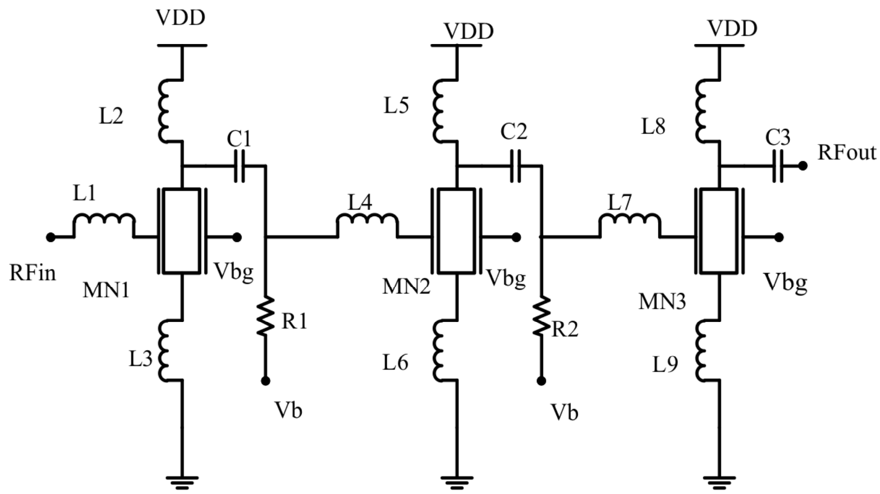

Figure 4: The circuit diagram of CS cascade DG-MOSFET PA circuit

The OOK Transmitter uses a DG- MOSFET common source (CS) three-staged class A power amplifier. The design is adopted from 9 and modified to 32 nm DG-FinFETtechnology [7].

III. HSPICE RF SIMULATION RESULTS

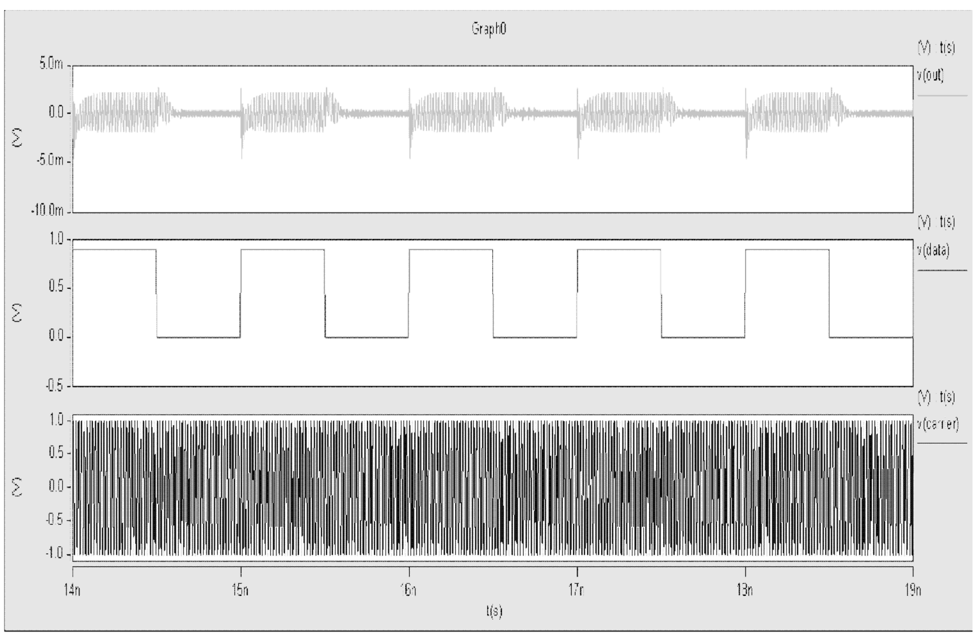

Figure 4: Transient analysis of proposed OOK modulator

IV. RESULTS AND CONCLUSION

Here we proposed the power efficient OOK modulator with better ON/OFF ratio. This proposed OOK modulator provides a greater stability to a transmitter. In this paper we successfully proved that, energy efficient 60 GHz transmitter can be build using 32nm DG FinFET technology. Hence we can say that FinFET technology can be good option for a CMOS technology in future. Here we obtained total average power dissipated is 4.64 mw and total current drawn by a circuit is 5.15 mA. By observing s-parameter and

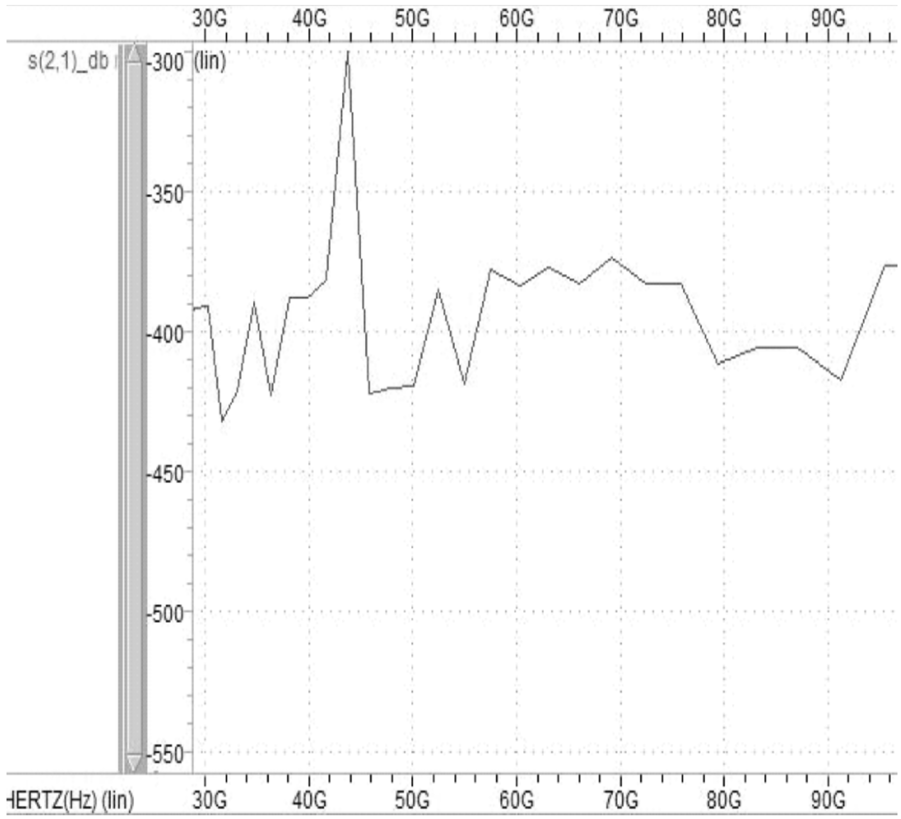

Figure 5: The S parameter (S_{21}) of an OOK transmitter

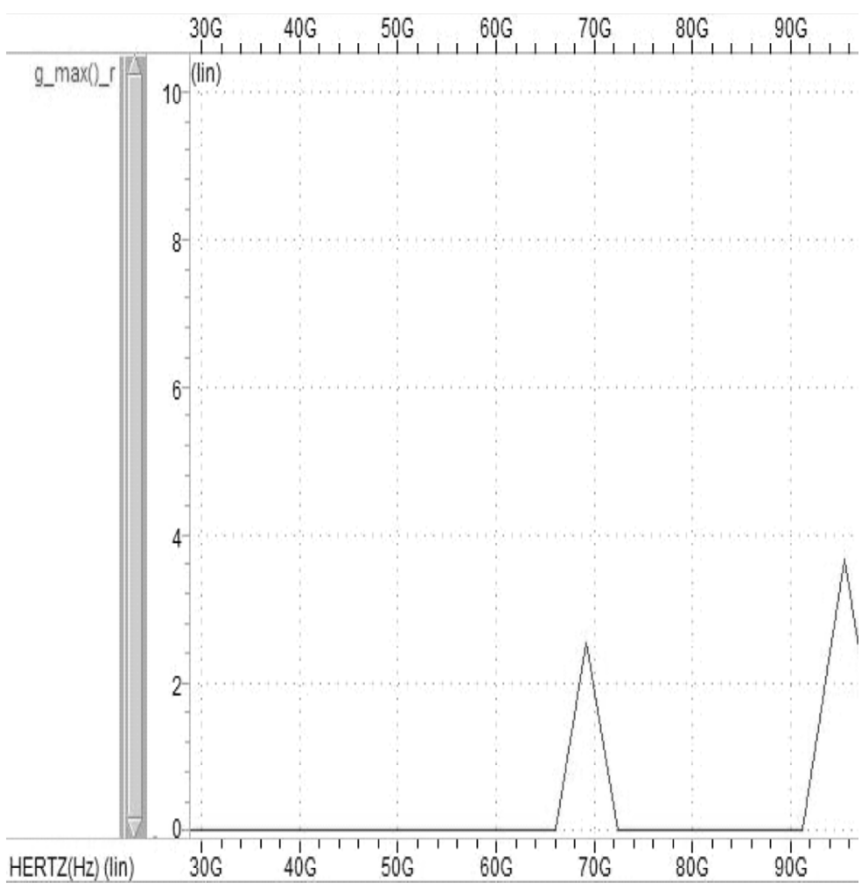

Figure 6: The maximum gain parameter of an OOK transmitter

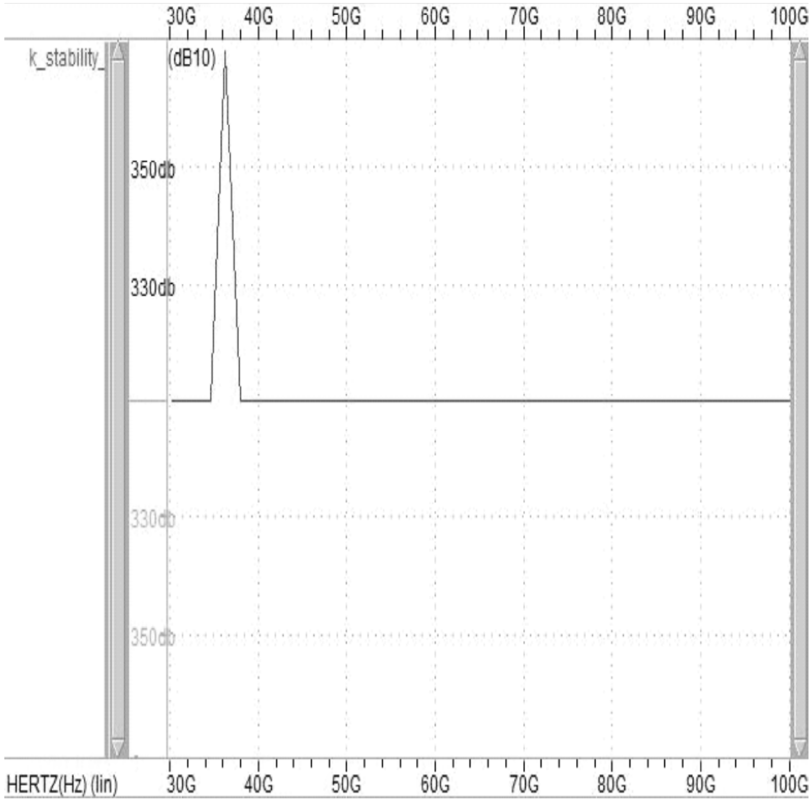

Figure 7: Stability factor of an OOK transmitter

stability factor we can say that the transmitter operates well with in an assumed parameter limits. The bandwidth of transmitter is 50 GHz and transistor can work up to 2.5 Gbps data rate for 60 GHz carrier.

V. REFERENCES

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