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Improvement in Performance of Oscillator in Time and Frequency Domain Using P-HEMT

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ABSTRACT

The Researches on Frequency controlled oscillator have been based on the areas of higher frequency, lower phase noise, low power, low operating frequency, and increased tuning range. However we can say that some objective achieved in the expense of other objectives. In this paper we analyse the design of Frequency Controlled Oscillator high performance in time and frequency domain using High Electron Mobility Transistor. The beginning of the paper is reviewing the basic information about High Electron Mobility Transistor. In this paper, we use MATLAB SIMULINK tool for simulation of proposed model of Frequency Controlled Oscillator based on the new technique p-HEMT. In this paper, results shown good agreement with basic parameter and modified parameter of p- HEMT.

Keywords: — Oscillator, p-HEMT, Time Domain, Frequency Domain .

I. INTRODUCTION

A system which generates output signal in form of periodic is known as oscillator. Voltage Controlled Oscillators (VCO) are oscillators in which the relation between output frequency and applied external Frequency is proportional [1]. An oscillator is one of the important things for all microwave systems such as radar, communications, navigations, or electronic warfare. Lumped-element tuning networks are used at low microwave and RF frequencies. Mostly, oscillator configurations are good for low power radio and microwave frequency oscillator design [2]. On the other hand, for radar and microwave heating systems, the vacuum devices is used that is the only high power RF source and microwave and radar heating systems are power oscillator rather than power amplifier [3]. Solid-state devices cannot compete this devices because these are use at kilowatt levels. As compared to the vacuum devices, high power Radio Frequency solid-state device technologies provides reduction in weight, size and improvement in low voltage power supply and reliability. In latest, the advanced technologies of solid-state RF transistors offer good quality with relatively low supply voltages and small size in the systems. On various aspects HEMT is highlighted since that has high breakdown voltage, high electron mobility, high thermal conductivity and low output capacitance to get the high efficiency characteristics and output power at high-frequency [4].

II. HIGH ELECTRON MOBILITY TRANSISTORS (HEMTs)

The high electron mobility transistor (HEMT), which is also named as hetero-structure field-effect transistor (HFET), two-dimensional electron gas field-effect transistor (TEGFET), modulation doped field-effect transistor (MODFET) or selectively doped hetero-structure transistor (SDHT), was invented about 20 years ago. The first HEMT device was reported in 1980 [4], after the successful growth of modulation doped AlGaAs/GaAs hetero-structure [5]. Formation of an electron potential well at hetero-interface occurs due to employing two semiconductor materials (AlGaAs/GaAs) with different band-gaps. The electrons are confined in this potential well to form a 2-DEG (Dimensional Electron Gas). Due to the 2-D feature of the electrons in this conduction channel, the carrier mobility can be enhanced remarkably.

The fundamental characteristic of the HEMT structure is the conduction band offset between the materials which construct the barrier and channel layers, that is, the barrier layer has a higher conduction band while the channel layer has a lower one. A potential well is then formed which can contain a large number of electrons to form a 2DEG channel at the hetero-interface due to this conduction band offset.

III. DEPLETION MODE P-HEMT BIAS NETWORKS

Standalone GaAs pHEMTs is that which require external bias and RF matching networks will provide good performance. Parameters such as gain, Noise Figure (NF), and pHEMT's bias point controlled linearity [6]. Note describes the many ways to properly bias a pHEMT and outlines the performance characteristics for each circuit.

In p-HEMT, bias conditions should achieve for both the gate and drain of a pHEMT for proper functioning. The drain voltage relative to the source (VDS) should be ≥ 2 V, while current flow from drain to source then its source must be of the gate voltage (IDD). Figure 2 shows the basic circuit representation of a pHEMT.

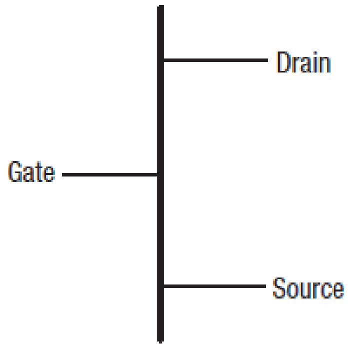

Fig. 1 Basic p-HEMT circuit representation

With VGS = 0 V and VDS ≥ 2 V, the FET is in its saturated state (IDSS) and draws the maximum amount of current. Lowering VGS to approximately –0.7 V, the device enters its pinchoff state and turns off. Figure 3 shown the characteristics of a Skyworks 200 µm FET.

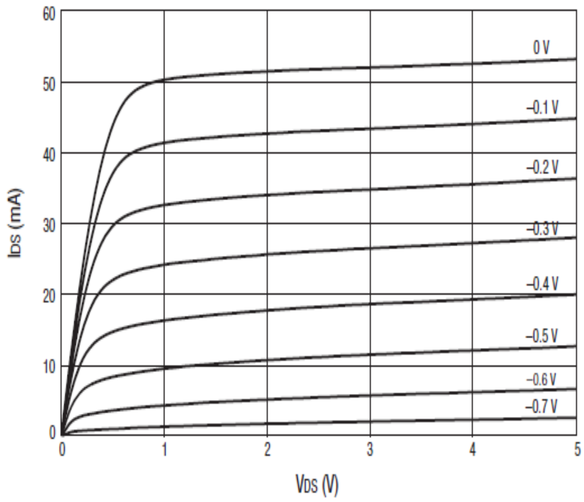

Fig. 2 Typical IV Characteristics for a 200 µm p-HEMT

IV. CONCEPT OF COLPITTS OSCILLATOR

Collpitts Oscillator basically consists of two parts: The resonator and active part. In proposed model design, common source series feedback is used. This design provides high trade-off between low phase noise and high gain as compared to parallel feedback configuration. In design, resonator using LC circuit and active circuit is designed as reflection amplifier. In circuit for providing feedback voltage capacitor C_1 and C_2 form potential divider. Across capacitor C_2 built voltage act as regenerative feedback which required for sustained oscillations and inductor in resonator part decides the frequency at which proposed circuit oscillates. Tank circuit gives 180^0 phase shift and transistor gives another feedback of 180^0, which is essential condition for oscillations.

V. DESIGN STEPS FOR COLPITTS OSCILLATOR

As shown in figure, capacitive feedback network is used to design reflection amplifier of colpitts oscillator. Ratio of capacitor C_1 and C_2 decides the amount of feedback. In this design, to obtain the sustained un-damped oscillations, an absolute value of open circuit voltage gain must exhibit by p-HEMT device which is greater than or equal to C_2/C_1 ratio. This condition ensure that gain of reflection transistor compensate the attenuation created by feedback network.

Here, the value of each capacitor is 1pF has been chosen. Frequency of oscillation gives by the resonant frequency of LC tank circuit

$$f = 1/ 2\prod\sqrt{L}*C_{eq}$$

where,

$$C_{eq} = C_1 * C_2 / C_1 + C_2$$

The volage of inductor (L) for tank circuit is calculated by modifying above equation

$L = 1/ (2\prod f)^2 C_{eq}$

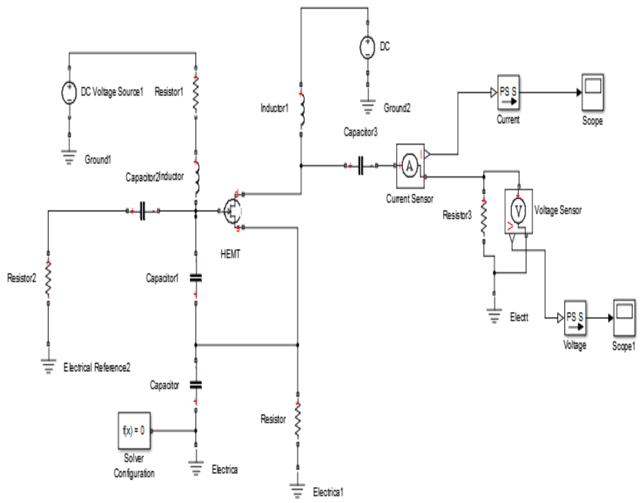

Fig. 3 Model of Collpitts Oscillator using p-HEMT

VI. SIMULATION RESULTS

Simulation works with a circuit of components. Each component performs its functioning according to their responsibility in whole simulation.

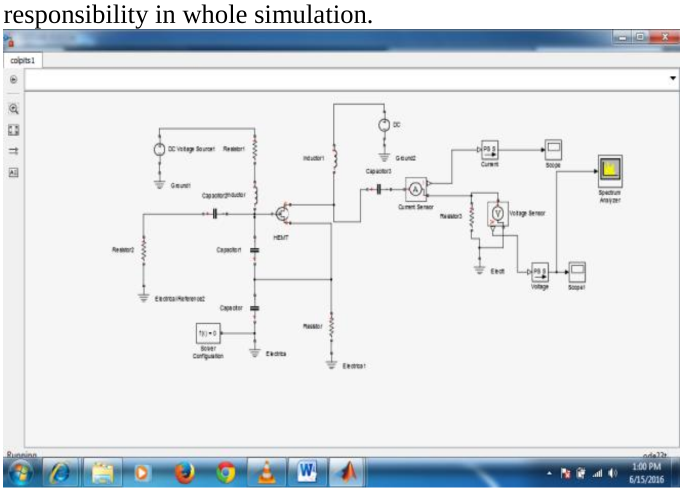

Fig. 4 Data is loaded and spectrum analyser is on processing.

Basic parameter used to check oscillator performance.

Table I: Basic Parameters for p-HEMT

Sr. No.	Parameter	Value
1.	Saturation Current	5e-10 A
2.	Threshold Voltage	-2.3 V
3.	Channel Length Modulation	0.003 1/V
4.	Measurement Temperature	25
5.	Source Resistance	1e-4 Ohm
6.	Drain Resistance	0.01 Ohm
7.	Input Capacitance	4.5 pF

This block represents an N-Channel JFET. The drain current Id for positive Vds (normal operation) is given by:

Id = 0 if Vgs-Vt0 < 0 (off)

Id = B*Vds*[2*(Vgs - Vt0) - Vds]*(1+L*|Vds|) if 0 < Vds < Vgs - Vt0] (linear region)

Id = B*(Vgs - Vt0)^2*(1+L*|Vds|) if 0 < Vgs - Vt0 < Vds (saturated region)

Where B is the Transconductance parameter, Vt0 is the Threshold voltage, L is the Channel-length modulation, Vgs is the gate-source voltage and Vds is the drain-source voltage.

On the basis of above parameters we get output of oscillator for current and voltage as represent following:

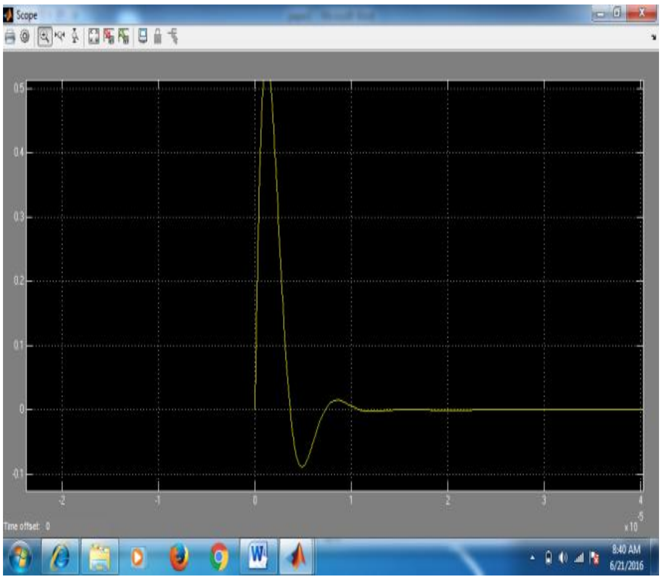

Fig. 5 This graph represents value for current

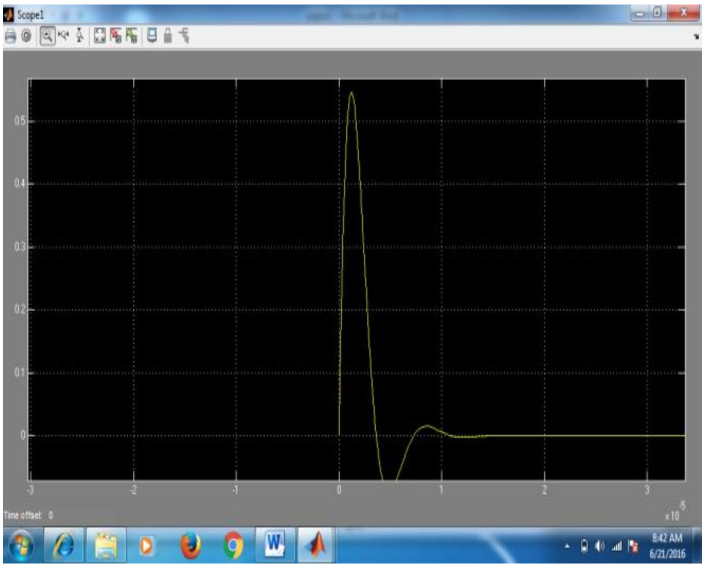

Fig. 6This graph represent value of voltage

Table II: Output with basic Parameters for p-HEMT

Sr. No.	Parameter	Value
1.	Gate reverse current, I_gss	-1 nA
2.	Saturated drain current, I_dss	3 Ma
3.	I_dss measurement point, [V_gs V_ds]	[0 15] V
4.	Small-signal parameters, [g_fs g_os]	[3e+3 10] uS
5.	Small-signal measurement point, [V_gs V_ds]	[0 15] V

Table III: Modified Parameters for p-HEMT

Sr. No.	Parameter	Value
1.	Saturation Current	5e-12 A
2.	Threshold Voltage	-1 V
3.	Channel Length Modulation	0.003 1/V
4.	Measurement Temperature	25
5.	Source Resistance	1e-4 Ohm
6.	Drain Resistance	0.01 Ohm
7.	Input Capacitance	4.5 pF

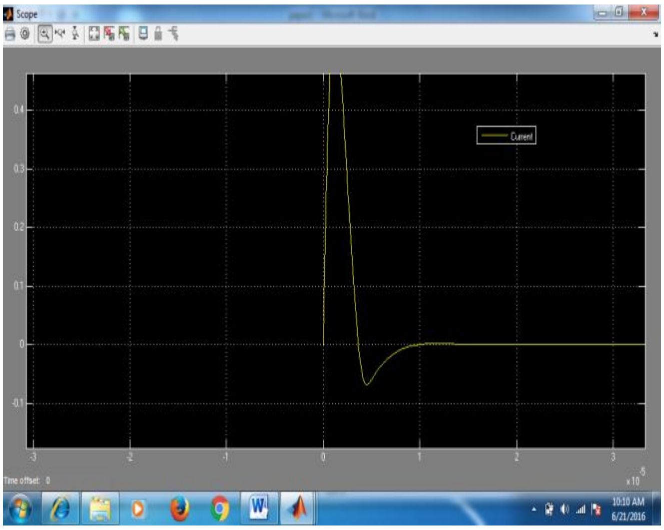

Fig. 7 This graph represents value for current

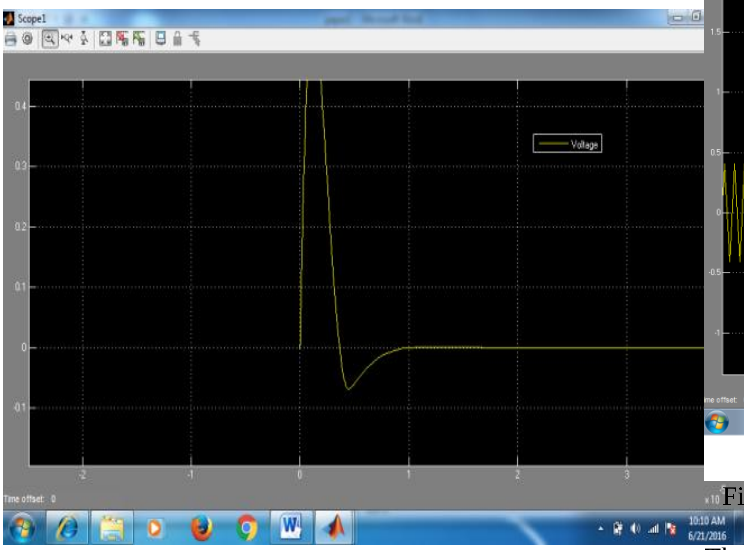

Fig. 8: This graph represent value of voltage

Table IV: Output with modified Parameters for p-HEMT

Sr. No.	Parameter	Value
1.	Gate reverse current, I_gss	-1.4 nA
2.	Saturated drain current, I_dss	4 mA
3.	I_dss measurement point, [V_gs V_ds]	[0 13] V
4.	Small-signal parameters, [g_fs g_os]	[3e+3 10] uS
5.	Small-signal measurement point, [V_gs V_ds]	[0 13] V

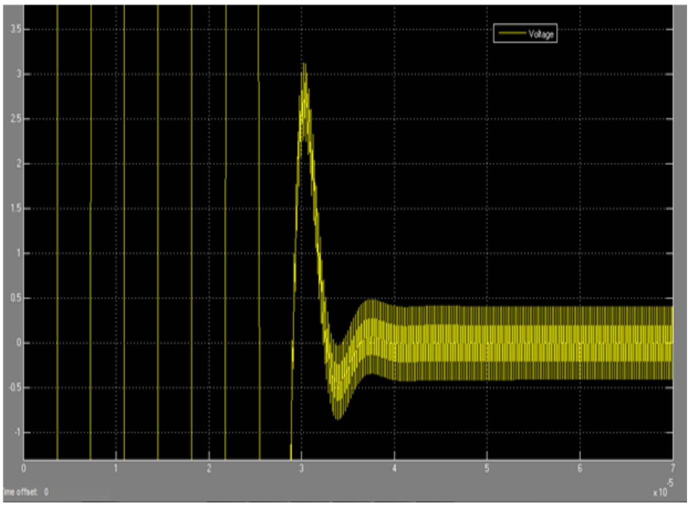

Fig. 9 Representation of voltage value in oscillation form

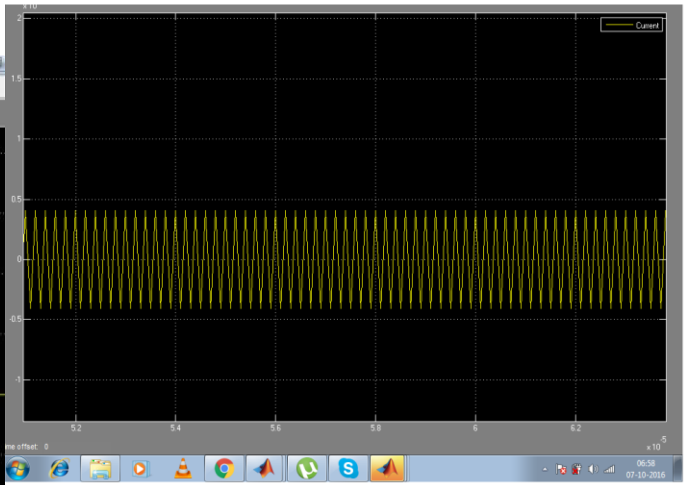

Fig. 10 Representation of current value in oscillation form

The oscillator performance using p-HEMT is displayed above in table form. First of all we need to measure the performance of oscillator with basic parameters which discussed in Table I. On basis of those parameters we execute the function and gain output which display in form of wave and Table II. Now we need some modification parameters of oscillator with p-HEMT, so we disturb the value of saturation current 5e- 10 A to new value 5e- 12 A and threshold voltage -1 V to -2.3 V due to which we got better results as displayed in Table IV. Value of Gate reverse current, I_gss is -1 nA in basic parameters which is goes in down that is -1.4 nA in modified results. This also the value of Saturated drain current, I_dss that is 4 mA in modified parameters at place of 3 mA in basic parameters. So we can say that improved in performance of pHEMT biased oscillator due to increase in value of reverse and drain current.

VII. CONCLUSIONS

A resonator configuration that is more suitable for the wide-band application. By series-parallel connection of integrated

HEMT, the effective capacitance modulation ratio is increased under large-signal conditions. Advanced active biasing technique that realizes the separation of current and voltage are an increased frequency range in comparison to the traditional passive realization. Furthermore, this solution allows to increase the current and voltage efficiency of the circuits and to decrease the chip-area demand. It can be done by terminating the FCO circuitry with appropriate load impedance the range of oscillations can be increased.

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