Small Signal Equivalent Circuit Model of MESFET with Effect of Transmission Line

Rashmita Kumari Panigrahy

Electronic Science Department, Berhampur University, Bhanja Bihar,
Berhampur, Odisha, INDIA-760007

Abstract

For the design of Integrated Circuit GaAs MESFET is Suitable by considering the transmission line character of the gate length at high frequencies. In the conducting channel, a stationary high field domain under saturation current condition. Small signal equivalent circuit of the channel is derived and equivalent circuit has been optimized by simulating average S-parameters for the process calculated between 1-65GHZ and 150 nm gate length of the device.

Keywords: Transmission line, MESFET, Small signal equivalent circuit, S-Parameters

I. Introduction

Accurate model of GaAs MESFET into circuit simulation it is necessary for proper fabrication of GaAs MESFET. Lumped element equivalent circuit is frequently utilized for GaAs Monolithic Microwave Integrated (MMIC) devices (1). The neutral channel is represented as a -Equivalent representation of the gate area, where the elements are directly tied to the device's physical design parameters. (2). Considered very short Gate length in (3). Microwave FET noise models evaluation by experimental method (4). Small signal modeling and linear distributed mixer of MESFET discussed (5, 6).

A small signal equivalent circuit has been created using the transmission line characteristics of the gate in the current analysis. Optimized by a modeling process and average S-parameter are calculated.

II. The Neutral Channel

It is necessary to maintain phase shift between source and gate of GaAs MESFET at high frequencies. By proper phase shift neutral part of the gate channel as transmission line. By varying the voltage along the channel, the channel thickness increases in the drain direction and results in a smaller channel cross-section. In association to depletion layer the channel capacitance per unit length decreases and channel resistance per unit length increases.

In modeling of GaAs MESFET in saturation the channel is model as a distributed resistance and capacitance coupled between start of the channel at x=0 and gate electrode. The transmission line properties of the gate region are investigated in terms of the π Equivalent representation related to the design parameter of the device.

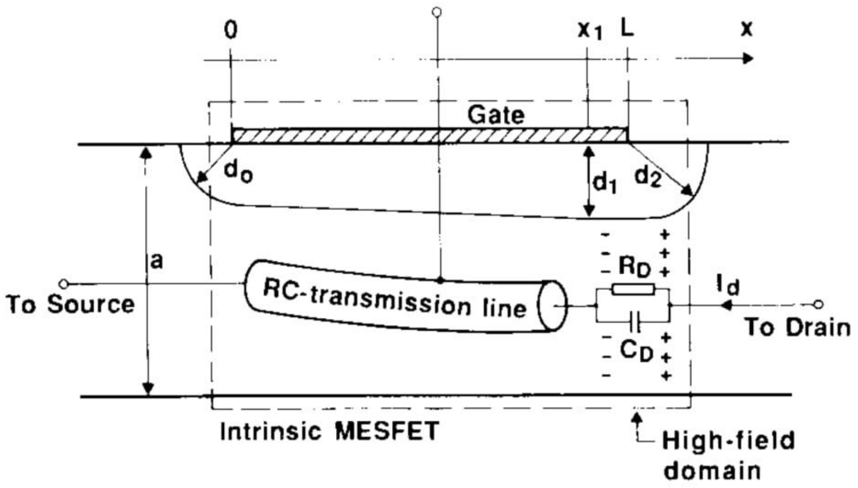

Figure.1 Cross Section of the gate region of the MESFET

Uniform Natural Channel

From the theory of RC transmission line of length 'l' can be represented as a π equivalent network. The π equivalent network consist of impedance Z_1, Z_2 , Z_3 , where $Z_2 = Z_3$ .The impedance element at circular frequency ω become

$$Z_1 = Z_0 \sinh(bl)$$
$$Z_2 = Z_3 = Z_0 \coth(bl/2)$$
$$Z_0 = (R/j\omega C)^{1/2} \quad , \quad bl = (j\omega RC)^{1/2}$$

Where Z_0 is the characteristic impedance of the line .The length of the line is taken to be equal to the length of the neutral channel under the gate. i. e $l = x_1 = (L-Wa)$.i.e at least approximation l=L

III.MESFET Equivalent Circuit:

The complete equivalent circuit of MESFET is shown below The equivalent circuit include the parasitic components connected to the terminal and the gate depletion zone's earring small signal equivalent current is i_D located parallel to the admittance. The transconductance related to the voltage difference $V_c = V_g - V_1$. . V_g the gate electrode voltage V_1 is the voltage at location $x=x_1$.In the small signal part v_c of V_c ,the drain current i_D is expressed as

$$i_D = g_{mc}\, v_c\, e^{-i\omega td}$$

The transconductance is frequency independent and the phase delay (td) is equal to the carrier transit time. Besides this other factor effect the delay time are capacitive coupling to gate and series inductance and various resistor.

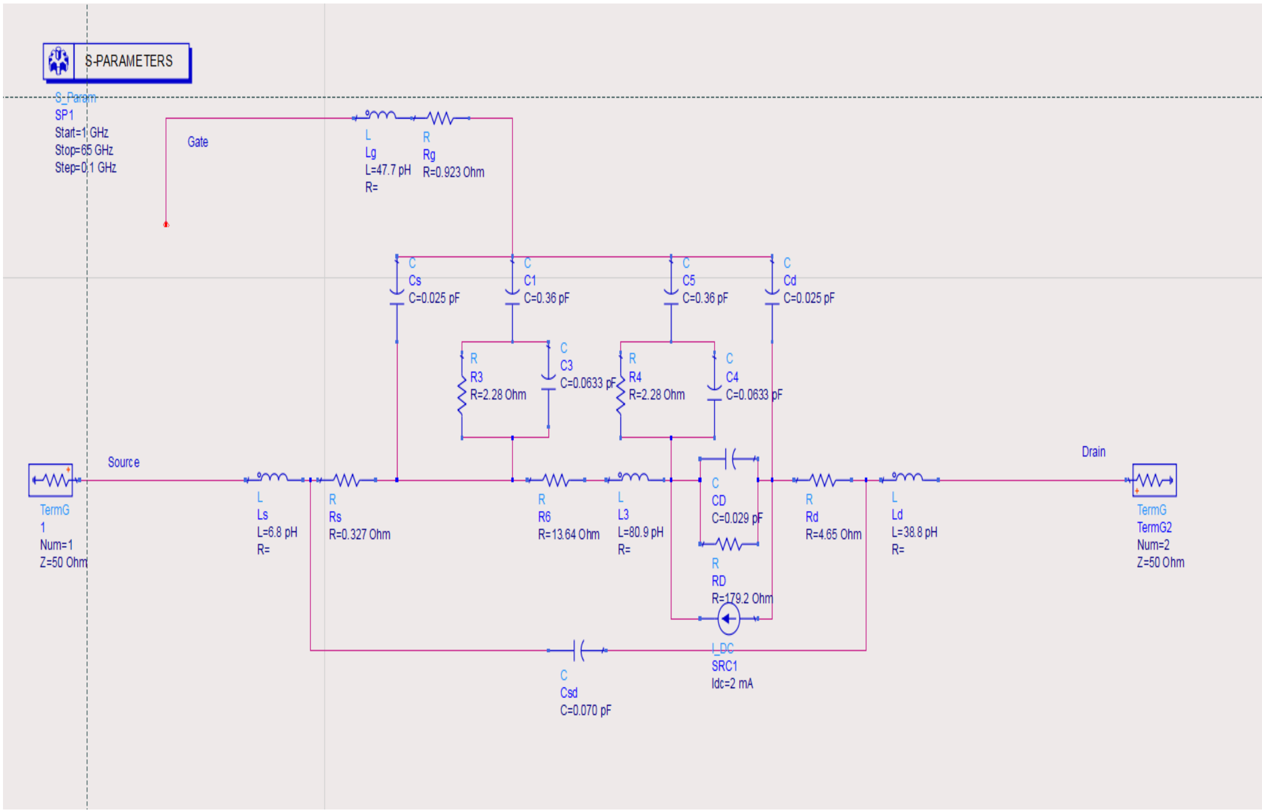

Figure.2 Small Signal Equivalent circuit for the GaAs MESFET

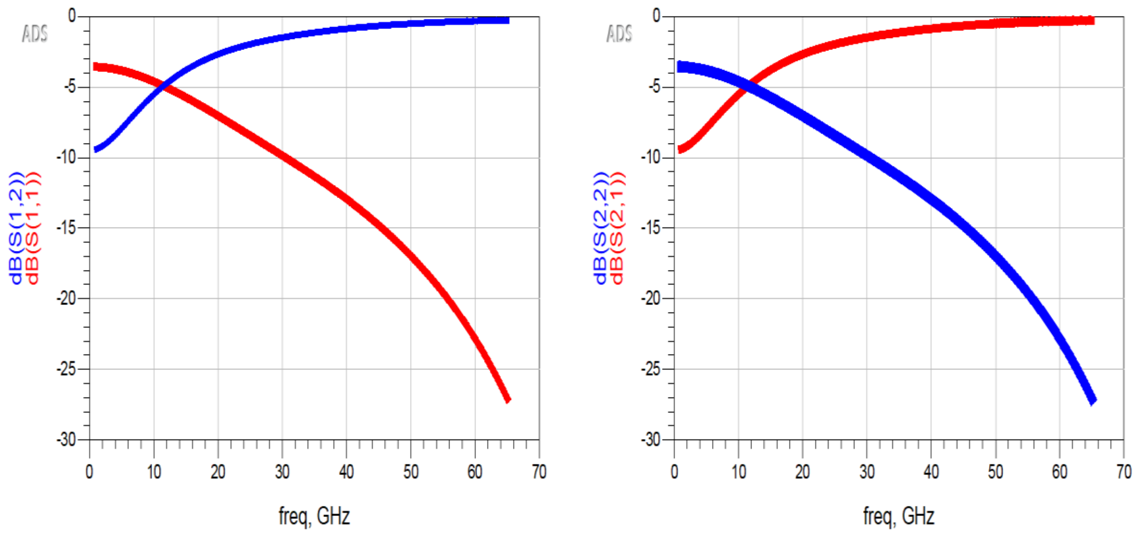

Figure.3 Magnitude of S-parameters obtained by optimization of present equivalent circuit with Vds=4 V and Vgs= -2V (Left side S11,S12 and Right side S21,S22)

The small signal equivalent circuit of GaAs MESFET , the capacitance C_s and C_d associated with the depletion zone extension of source and drain side of the gate.
The source side extension model as a quarter circle of radius $d_0 = a[(V_{bi} - V_g + V_d + R_s I_d)/Vp]^{½}$.$d_1 = a[V_{bi} – V_g + R_s I_d + E_s L)/V_p]^{½}$ and $d_2 = a[(V_{bi} - V_g + R_s I_d + E_s L)/Vp]^{½}$.

IV .Optimization

The small signal equivalent derived here by ADS process can be evaluated by performing optimization against S-parameter. Optimization based on 65 equally
Spaced frequencies in the range 1-65 GHZ. For 150nm MESFET the common source parameter used for biasing condition having Vds=4volt and Vgs=-2volt. The result of the optimization present in the above diagram. Sensitivity quantities such as stability factor, admittance parameter are derived from S-parameters.

MESFET Equivalent Circuit Parameters

(V_{ds} =4volt,V_{gs}=-2volts)

Sl.no	Parasitic Values
1.	R =13.64 ohms L =80.9pH C =0.633pF Rd =4.65 ohms Ld =38.8pH Cd = 0.034pF Rg =0.923 ohms Lg = 47.7pH RD =179.2 ohms CD =0.029pF Rs = 0.327 ohms Cs = 0.025pF Ls = 6.8 pH Gmc = 94.2

V.CONCLUSION:

For GaAS MESFET a new small signal equivalent developed by ADS and we analyze the transmission line properties of the neutral channel. This model tested for 1-65GHZ frequencies and compared the S-parameter of a 25µm GaAS MESFET. Fig 3 shows that this model. The basic structure of the present small signal GaAs MESFET also applicable to other FET design.

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