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ANALYTICAL MODEL PARAMETERS EXTRACTION TECHNIQUES FOR GAN HEMT DEVICE

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Abstract:

In this work, InAlGaN/GaN high electron mobility transistors (GaN HEMTs) device with cap layer had been designed and optimized using Silvaco Atlas simulator with the size of (0.5 ×1) µm. A small signal equivalent circuit of GaN high electron mobility transistor is built. Different techniques are applied to obtain the extrinsic and intrinsic parameters of the simulated device. The elements of the produced equivalent circuit are directly computed at different bias conditions and frequencies with different frequency ranges low medium and high frequencies (0.1GHz, 20GHz, and 45GHz) respectively. In this work, small signal S-parameters are used to extract the device parameters by using different techniques. These parameters are inserted into the Advance Design System (ADS) to build the GaN HEMT model. Then, small signal S-parameters of the simulated device validated with the S-parameters results from the modeled device in ADS. Good results have been obtained from the DC and RF characteristics comparison at a wide range of frequencies which make the designed model a good choice for microwave applications.

Keywords: *Advance design system, GaN HEMT, Intrinsic, Extrinsic, cold, and Hot-FET.*

1 INTRODUCTION

Many techniques have been proposed for transistor extraction parameters. The majority of these measurements were based on a combination of small-signal S-parameters and DC parameters that were obtained under specific bias conditions (R. Anholt and S. Swirhun, 1991), (G. Dambrine, A. Cappy, et.al.,1988). Dambrine and Cappy in (G. Dambrine, A. Cappy, et.al.,1988) proposed a technique to extract the parameters of FETs. In (A. Mishra, A. Khusro, et.al.,2017) the article presents a small signal equivalent circuit model of AlGaN/GaN High Electron Mobility Transistor (HEMT) based on the parameter extraction approach, depending on the cold-FET situation. The unidentified factors of the proposed GaN HEMT device are split into two categories: - the extrinsic, and the intrinsic i.e. the transistor's core parameters. The intrinsic parameters represent bias-dependent elements whereas the extrinsic parameters represent bias-independent elements. Two procedures can be used to extract the extrinsic and intrinsic parameters of the device. Firstly, Cold-FET S-parameters are used to obtain the extrinsic parameters. Then, Hot-FET S- parameters are applied to extract the intrinsic parameters. The extrinsic elements are extracted from cold S-parameter data due to the equivalent circuit's ability to be greatly simplified at zero drain-source voltage i.e.(Vds=0V). The term "cold" refers, as its name implies, to the equivalent temperature related to the mean energy of motion of the channel electrons when linear electric field is applied (G. Crupi, A. Caddemi,et.al.,2016).

In this paper, InAlGaN/GaN HEMTs of (0.5×1µm) which are grown on silicon carbide (Sic) substrate HEMT heterojunction device with cap layer and Silicon Nitride (Si_3N_4) passivation layer have been simulated using Silvaco Atlas simulator as shown in Figure (1). The AC and DC responses with RF characteristics were investigated. The simulated device has been modeled using small signal s-parameters. Cold-FET s-parameters are used to extract the extrinsic parameters. The intrinsic parameters are extracted similarly using the Hot-FET s-parameters. Advanced design and system (ADS) is used to build the model.

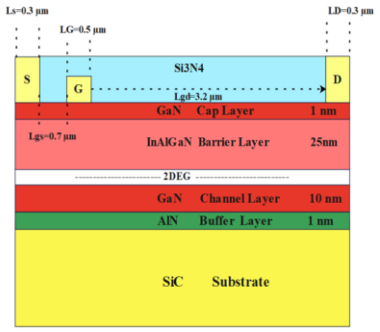

Figure 1. The Proposed Structure of the InAlGaN/GaN with Passivation Layer (Si3N4)

▪ 2 THE PROCEDURE OF EXTRINSIC AND INTRINSIC PARAMETERS EXTRACTION

Two procedures can be used to extract the extrinsic and intrinsic parameters of the device.it is possible to extract the intrinsic parameters using Hot-FET s-parameters and the extrinsic parameters using Cold-FET S-parameters. In this section, cold and hot-FET techniques are used to extract the parameters of the simulated device. The equivalent circuit in (M. Berroth and R. Bosch,1991) is used in this work. The small signal equivalent circuit of GaN HEMT on SiC simulated device is chosen for this work and is presented in Figure (2). The circuit inside the shaded rectangular in Figure (2) represents the intrinsic parameters, where the elements outside the rectangular are the extrinsic elements.

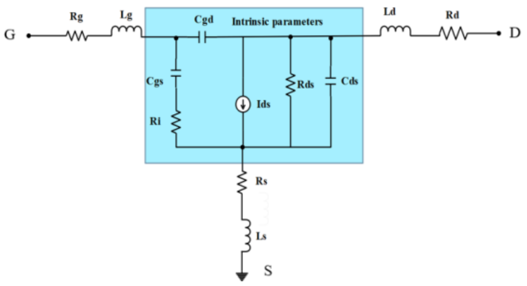

Figure 2. Equivalent Circuit of GaN HEMT (M. Berroth and R. Bosch,1991)

2.1 Cold-FET S-parameters Techniques

The extrinsic parameters consist of pad capacitors (which are ignored in this work), the contact resistors resistive (R_g, R_s, and R_d) and the metallization inductances (L_g, L_s, and L_d) are extrinsic elements as shown in Figure (3). These parameters are extracted at high frequency according t (Y. Chen et al,2020), and (R. G. Brady, et.al.,2008) by using Cold-FET techniques.

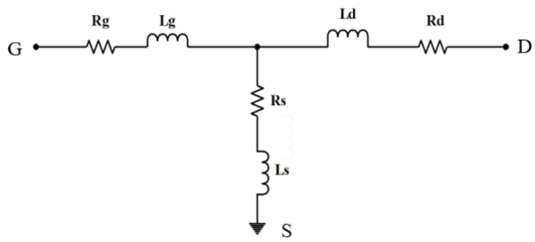

Figure 3. Equivalent Circuit of Extrinsic Parameters (R. Tayrani et.al., 1993)

Cold-FET technique means that drain-source voltage must equal zero to delete the effect of the intrinsic parameters and calculate the parasitic inductors and resistors of the transistor. There are three types of Cold-FET techniques based on the bias condition of the gate-source voltage. The techniques that have been used to extract the extrinsic parameters are: -

2.1.1 Forward Cold-FET Technique

In the Forward bias condition, the drain voltage is equal to zero volts ($V_{ds} = 0V$) and the gate-source voltage is greater than zero (V_{gs}≫0V). The Z-parameters are used to extract the extrinsic resistors and inductors of our GaN device. The equivalent circuit at this bias condition is as shown in Figure (4).

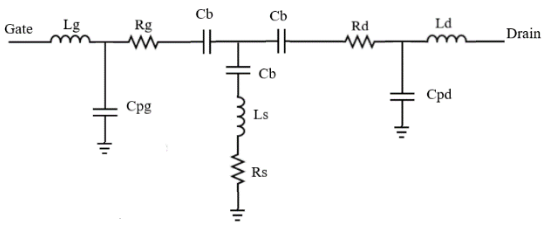

Figure 4. Forward Equivalent Circuit (R. Tayrani et.al., 1993)

2.1.2. Unbiased cold-FET Technique

For cold-FET unbiased condition, the drain voltage and gate-source voltage are both equal to zero volts i.e. (V_{ds}=0V and V_{gs}=0V). The Z-parameters are used to extract the extrinsic resistors and inductors of our GaN device. The equivalent circuit at this bias condition is shown in Figure (5).

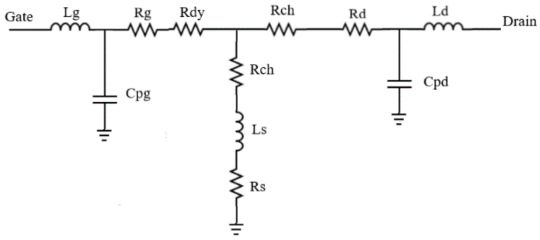

Figure 5. Unbiased Equivalent Circuit (R. Tayrani et.al., 1993)

2.1.3. Pinch-off cold-FET technique

In this bias condition, the drain voltage is equal to zero volt (i.e. V_{ds}=0V) and gate source voltage of (V_{gs}) is equal to pinch-off voltage. The pad capacitors (C_{pd} and C_{pg}) are extracted in this bias condition. The capacitors must be extracted at intermediate and high frequency range using the Y-parameters. The equivalent circuit at this bias condition is shown in Figure (7) below.

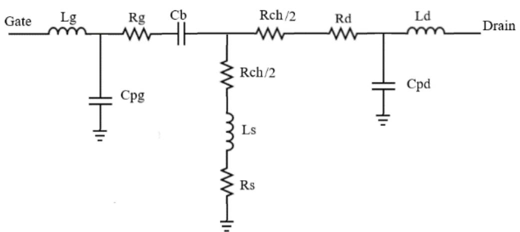

Figure 6. Pinch-off Equivalent Circuit (R. Tayrani et.al., 1993)

2.2 Hot-FET S-parameters Technique

In this section, the intrinsic parameters were de-embedded using the method of Dambrine and Cappy(G. Dambrine, A. Cappy, et.al.,1988). The s-parameters results from the simulation of the GaN HEMT device represent the completed device s-parameters. So, to extract the intrinsic parameters of our device the S-parameters must be converted to the Z-parameters to de-embed the extrinsic parasitic inductance (L_s, L_g, and L_d), then the Z-parameters to are converted to the Y-parameters to de-embed the pad capacitors (Cpd and Cpg), and to de-embed the extrinsic parasitic resistors (Rs, Rg and Rd) the Y-parameters was converted to Z-parameters. Finally, the last Z-parameters were converted to Y-parameters which were used to extract the intrinsic parameters (R_i, R_{ds}, g_m, τ, C_{ds}, C_{gd} and, C_{gs}) of the device. Table (1) shows the sequence of the method of de-embedding the intrinsic device parameters.

3. Proposed method: -

3.1 Extrinsic parameters

To extract the extrinsic parameters, the cold-FET technique can be used. In this technique, the drain voltage must be set to zero value (V_{ds}=0V), and the gate to source voltage is set to particular value that make the device on forward, unbiased or pinch-off state. The proposed device is GaN HEMT which is normally on and a particular negative voltage is needed to site the device on off state. Therefore, the gate source voltage (V_{gs}) must be adjusted to (-4V) and the drain source voltage (V_{ds}) must be equal to zero volts in order to meet the unbiased cold-FET requirement. While the gate source voltage must be equal to (-6V) and the drain source voltage must equal zero for a pinch-off cold-FET situation. In a forward cold-FET configuration, the drain voltage is equal to zero volts and the gate source voltage is equal to (-3V or -2V).

3.1.1. Z_{22} Parameters Extraction: -

From the real part of the impedance element Z_{22}, the estimated values have been calculated using the equations (1-4) (R. G. Brady, et.al.,2008).

$$R_{ch} \approx Re(Z_{22}|f_L - Z_{22}|f_H) \ldots (1)$$

$$R_d + R_s \approx Re(Z_{22}|f_H) \ldots (2)$$

$$C_{ds} \approx \frac{1}{w_M R_{ch}}\left(\frac{R_{ch}}{Re(Z_{22}|f_M - Z_{22}|f_H)} - 1\right)^{\frac{1}{2}} \ldots (3)$$

$$L_d + L_s \approx \frac{1}{w_H} Im\left(Z_{22}|f_H - \frac{R_{ch}}{1 + jw_H C_{ds} R_{ch}}\right) \ldots (4)$$

Where W=2πf. The extrinsic parameters L_g, L_s, L_d, Cpd, Cpg, all inter-electrode capacitances, and gate current conductance have been disregarded in (P. Someswaran,2015) because Silvaco does not contain gate leakage models and does not account for parasitic of any kind in its simulations. In this work,

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the pad capacitors (C_{pd} and C_{pg}) have been ignored. The obtained values have been determined at 0.1 GHz, 20 GHz, and 45 GHz, respectively, at the lowest, middle, and maximum frequencies which are denoted by L, M, and H in equations.

3.1.2. Z_{12} Parameters Extraction: -

Real and imaginary component of Z_{12} have been used to extract the source resistor R_s and source inductance Ls. The equations (5 and 6) from (R. G. Brady, et.al.,2008) listed below are used to calculate these values. The values of Z12 parameter are extracted at high frequency (45GHz).

$$R_s \approx Re(Z_{22}|f_H)\ldots (5)$$

$$L_s \approx \frac{1}{w_H} Im\left(Z_{12}|f_H - \frac{\frac{1}{2}R_{ch}}{1+jw_H C_{ds} R_{ch}}\right)\ldots (6)$$

3.1.3. Z_{11} Parameters Extraction: -

From Z_{11} parameters the remain value that represent the extrinsic values of the device can be extracted. The equation (7-10) from (R. G. Brady, et.al.,2008) are used to get these values. These values Cg and R_{dy} are calculated at low frequency where L_g and Ls are calculated at high frequency.

$$C_g \approx \frac{1}{w_L} Im\left(Z_{11}|f_L - \frac{\frac{1}{3}R_{ch}}{1+jw_L C_{ds} R_{ch}}\right)^{-1} \ldots (7)$$

$$R_{dy} \approx \frac{1}{(w_L C_g)^2} Re\left(Z_{11}|f_L - \frac{\frac{1}{3}R_{ch}}{1+jw_L C_{ds} R_{ch}}\right)^{-1} \ldots (8)$$

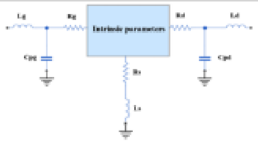
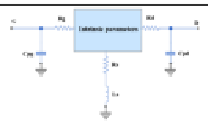
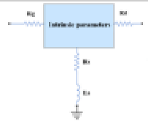
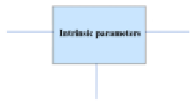
$$R_g + R_s \approx Re(Z_{11}|f_H) \ldots (9)$$

$$L_g + L_s \approx \frac{1}{w_H} Im\left(Z_{11}|f_H - \frac{\frac{1}{3}R_{ch}}{1+jw_H C_{ds} R_{ch}} - \frac{R_{dy}}{1+jw_H C_g R_{dy}}\right) \ldots (10)$$

3.2 Intrinsic parameters

The intrinsic elements were extracted under Hot FET with multi bias condition(R. G. Brady, et.al.,2008) . There are eight intrinsic parameters must be extracted by using real and imaginary parts of the Y–parameters eight equations. The equations in the range (11 to 20) are valid for hot-FETs, which means that the gate source voltage can be positive or negative and the drain source voltage must be larger than zero (V_{ds}>0V) by Berroth and Bosch (M. Berroth and R. Bosch,1991). Additionally, the equivalent circuit can run at any frequency using these equations (M. Berroth and R. Bosch,1991). The following eight equations are used to extract the eight intrinsic parameter: -

Table 1. De-embedded the Intrinsic parameters

	Procedure	Parameter	Circuit
1	Simulate the device at Hot-FET condition to obtain the s-parameters.	$S = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix}$	
2	Convert the S to Z to eliminate (L_g, L_d)	$Z = \begin{bmatrix} Z_{11} - jwL_g & Z_{12} \\ Z_{21} & Z_{22} - jwL_d \end{bmatrix}$	
3	Convert the Z to Y to eliminate $(Cpg\ and\ Cpd)$	$Y = \begin{bmatrix} Y_{11} - jwC_{pg} & Y_{12} \\ Y_{21} & Y_{22} - jwC_{pd} \end{bmatrix}$	
4	Convert the Y to Z to eliminate (R_s, R_g and R_d $and\ Ls$)	$Z = \begin{bmatrix} Z_{11} - R_s - R_g - jwL_S & Z_{12} - R_s - jwL_s \\ Z_{21} - R_s - jwL_S & Z_{22} - R_s - R_d - jwL_s \end{bmatrix}$	
5	Convert the Z to Y	$Y = \begin{bmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{bmatrix}$	

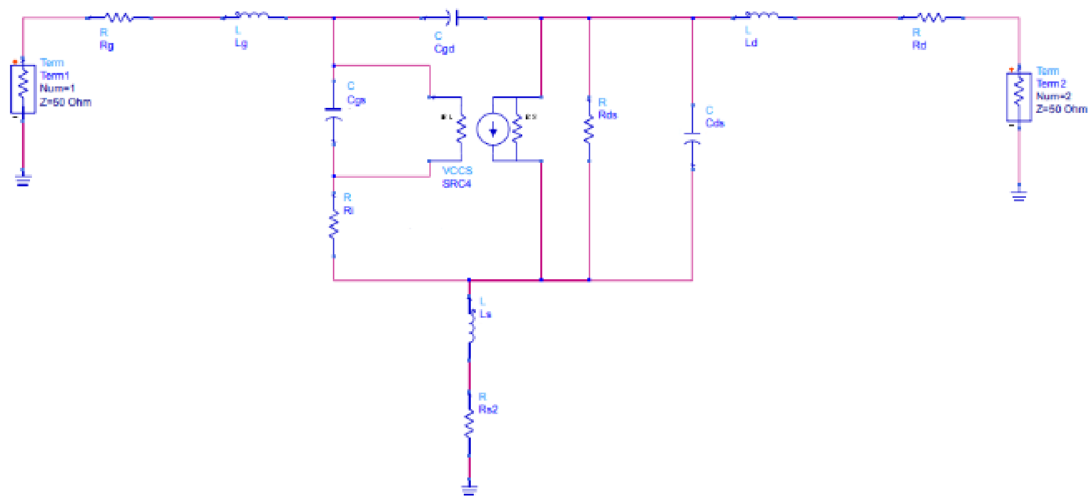


Figure 7. GaN HEMT Model

$$d(w_i) = \frac{Re\left(Y_{11}(w_i) + Y_{12}(w_i)\right)}{Im\left(Y_{11}(w_i) + Y_{12}(w_i)\right)} \quad \dots (11)$$

$$c(w_i) = \left(Y_{21}(w_i) - Y_{12}(w_i)\right)(1 + jd(w_i)) \dots (12)$$

$$R_i(w_i) = \frac{d^2(w_i)}{(1 + d^2(w_i))Re(Y_{11}(w_i) + Y_{12}(w_i))} \quad \dots (13)$$

$$g_m(w_i) = |c(w_i)| \quad \dots (14)$$

$$\tau(w_i) = -\frac{1}{w_i}\arctan\left(\frac{Im(c(w_i))}{Re(c(w_i))}\right) \quad \dots (15)$$

$$g_{ds}(w_i) = Re(Y_{22}(w_i) + Y_{12}(w_i)) \quad \dots (16)$$

$$C_{ds}(w_i) = \frac{Im(Y_{22}(w_i) + Y_{12}(w_i))}{w_i} \quad \dots (17)$$

$$C_{gd}(w_i) = \frac{Im(Y_{12}(w_i))}{w_i}\left[1 + \left[\frac{Re(Y_{12}(w_i))}{Im(Y_{12}(w_i))}\right]^2\right]$$

$$C_{gd}(w_i) = \frac{-Im(Y_{12}(w_i))}{w_i} \quad \dots (18)$$

$$C_{gs}(w_i) = \frac{1 + d^2(w_i)}{w_i} Im(Y_{22}(w_i) + Y_{12}(w_i)) \quad \dots (19)$$

$$R_{gd}(w_i) = \frac{\frac{Re(Y_{12}(w_i))}{Im(Y_{12}(w_i))}}{ImY_{12}(w_i)\left[1 + \left[\frac{Re(Y_{12}(w_i))}{Im(Y_{12}(w_i))}\right]^2\right]} \quad \dots (20)$$

For good results the parasitic resistors from forward bias condition Cold-FET technique and the parasitic inductors from unbiased condition Cold-FET technique with Hot-FET S-parameters have been chosen to extract the intrinsic parameters. Additionally, using the pinch-off condition Cold-FET technique, parasitic capacitors can be extracted.

4. Result and Discussion: -

Cold-FET s-parameters techniques and Hot-FET technique were utilized to extract the parameters of simulated device. The extrinsic and intrinsic properties (14-element's parameters) of the simulated device are displayed in Table (2). For the purpose of connecting the measured S-Parameters with the electrical processes that take place in GaN HEMT, small signal models are required. Every component in the model approximates a particular element of the device's physical properties using lumped elements. Figure (7) displays the small signal equivalent model of the optimized GaN HEMT device.

The s-parameters that have been obtained from the Silvaco simulator of the GaN HEMT device are inserted into ADS in the S-parameter file block as a touchstone file as shown in Figure (8).

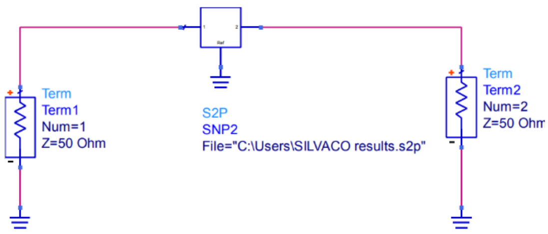


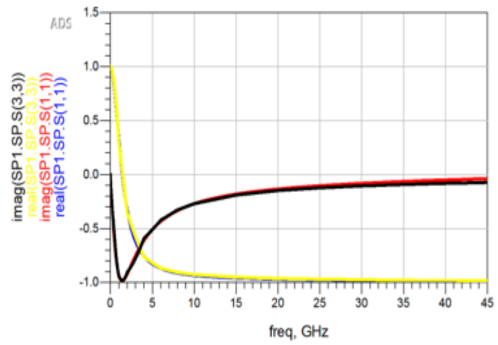
Figure 8. S-parameters of simulated GaN HEMT Device

The extrinsic and intrinsic properties (14-element parameters) of the simulated device are displayed in Table (2). The results determined by the Matlab program through analytical approaches are represented by the calculated values in the first column in Table (2). On the other hand, the fitted values in the second column of Table (2) are the result of fine-tuning of the calculated values using ADS software. Without having to stimulate the design in ADS, tuning allows researchers to simply change the value of a variable and observe the impact on the response data.

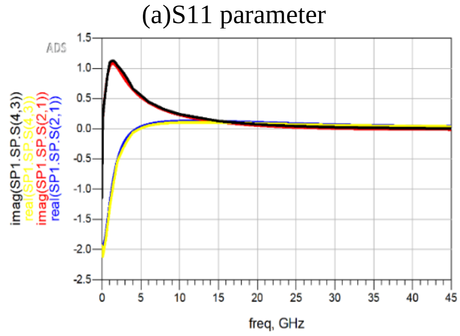
Table 2. Extrinsic and Intrinsic Parameters

parameters	Calculated values	Fitted values	Bias condition
$R_s(\Omega)$	0.152	0.12616	Forward cold-FET V_{ds}=0V , V_{gs}=-2V
$R_g(\Omega)$	0.0568	0.0557	
$R_d(\Omega)$	0.44	0.66	
$L_s(pH)$	0.2304	0.115175	Unbiased cold-FET V_{ds}=0V , V_{gs}=-2V
$L_g(pH)$	2.95	2.95	
$L_d(pH)$	0.3115	0.3115	
$R_i(\Omega)$	0.095	0.095	Hot-FET V_{ds} = 5.5V , V_{gs}=0V
$R_{gd}(\Omega)$	3.411	3.411	
$g_{ds}(S)$	0.1506	0.3145	
$g_m(S)$	0.288	0.316	
$\tau(psec)$	2.758	2.758	
$C_{ds}(pH)$	3	2.12	Cold-FET V_{ds} = 0V , V_{gs}= -6V
$C_{gd}(pH)$	0.85	0.276	
$C_{gs}(pH)$	1.5	1.693	

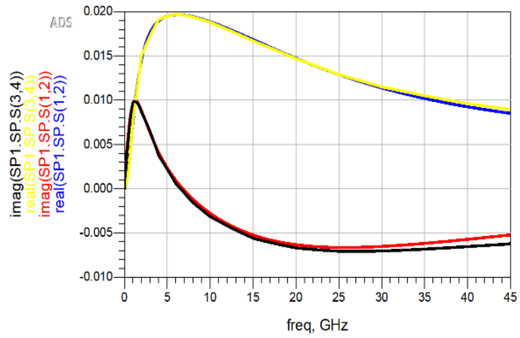
For verification of the parameter extraction method and the model of the GaN HEMT device, the s-parameters from the Silvaco simulator are entered into ADS in the s-parameter file block as a touchstone file. These are then compared to the s-parameters of the equivalent circuit, which was created using the extracted parameters from Table (2) in Figure (7) of the GaN HEMT device that has been designed. A good agreement can be shown for a broad range of frequencies as shown in Figure (9). The DC characteristics of the modeled GaN HEMT device compared with the simulated device are shown in Figure (10). Since the Chalmers (Angelov) nonlinear model (I. Angelov, et.al.,1992), (I. Angelov, et.al,1992), (I. Angelov, N. Rorsman,1999) is a popular empirical model and one of the most often used GaN HEMT models, it has been used in this work. The standard Angelov GaN FET Model is used to build the simulated device into the ADS. A good verification has been obtained from IV characteristics as shown in Figure (10).



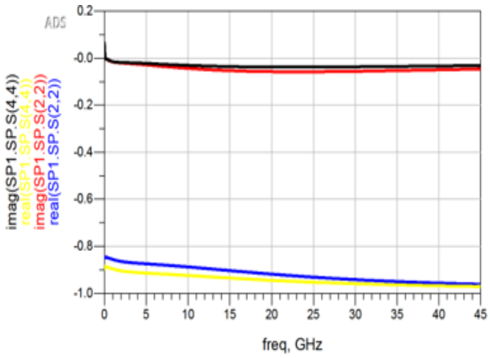
(a)S11 parameter



(b) S21 parameter



(c) S12 parameter



(d) S22 parameter

Figure 9. Validation of S-parameters of the GaN HEMT

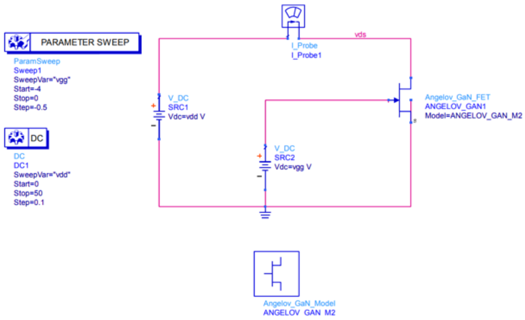
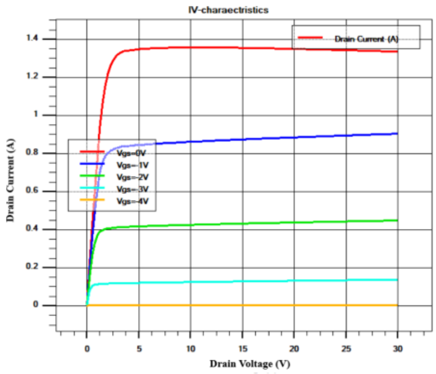
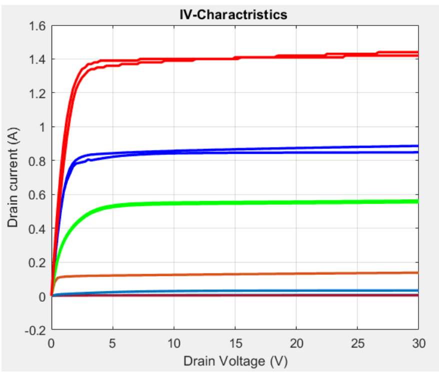


Figure 10. Biasing of the Rectangular Gate GaN HEMT Device

The modeled GaN HEMT is fed with high V_{ds} which is equal to $50V$ with varying levels of V_{gs} from $0V$ to $-4V$ in order to determine the break-down voltage of the device as shown in Figure (11).



(a)



(b)

Figure 11. (a) IV-characteristic from Silvaco. (b) Verification Results

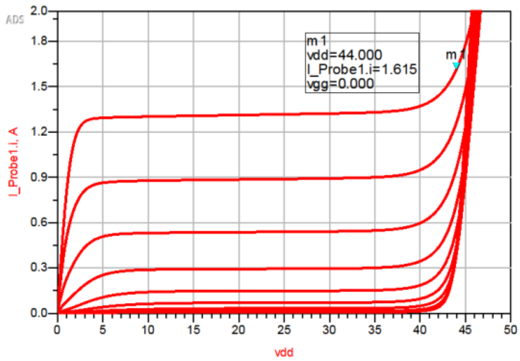


Figure 12. Break-down voltage of the modeled GaN HEMT Device

As a result, the optimized GaN HEMT device (which has been designed using Silvaco simulator) InAlGaN/GaN on Sic substrate is modeled. The components of the equivalent circuit are directly computed at different bias conditions and different frequency ranges low, medium, and high frequencies (0.1GHz, 20GHz and 45GHz) respectively. Cold-FET s-parameters techniques and Hot-FET techniques are utilized to extract the parameters of the simulated device. The 14-element's extracted parameters exhibit good agreement over a wide frequency range. Additionally, the results support the validity of the technique for extracting the extrinsic and intrinsic parameters. The flow chart in Figure (13) explains the methods that have been used to extract the extrinsic and intrinsic parameters using cold-FET and Hot-FET s-parameters techniques of the simulated GaN HEMT device.

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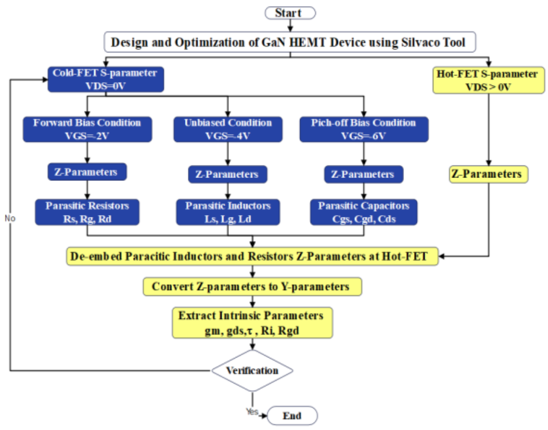

Figure 13. Flow chart of the Extrinsic and Intrinsic Parameters Extraction

5. Conclusion: -

In this study, a GaN high electron mobility transistor's small signal equivalent circuit is constructed. The optimized device (which have been designed using Silvaco simulator) InAlGaN/GaN on Sic substrate for (0.5×1µm) is modeled. The components of the equivalent circuit are direct computed at different bias conditions and different frequency ranges low medium and high frequencies (0.1GHz, 20GHz and 45GHz) respectively. Cold-FET s-parameters techniques and Hot-FET technique were utilized to obtain the parameters of the simulated device. The 14-element's extracted parameters exhibit good agreement over a broad frequency range which makes the device a good choice in microwave applications. Additionally, the IV characteristics from the Silvaco simulator agree with that obtained from the Angelov model. These results support the validity of the technique for extracting the extrinsic and intrinsic parameters for the Angelov model.

REFERENCES

A. Mishra, A. Khusro, M. S. Hashmi and A. Q. Ansari, "Modeling and parameter extraction method for AlGaN/GaN HEMT," 2017 International Conference on Multimedia, Signal Processing and Communication Technologies (IMPACT), Aligarh, India, 2017, pp. 214-217, DOI: 10.1109/MSPCT.2017.8364007.

G. Dambrine, A. Cappy, F. Heliodore, and E. Playez, “A new method for determining the FET small-signal equivalent circuit,” IEEE Transactions on microwave theory and techniques, vol. 36, no. 7, pp. 1151–1159, 1988. DOI: 10.1109/22.3650.

G. Crupi, A. Caddemi, D. M.-P. Schreurs, and G. Dambrine, “The large world of FET small-signal equivalent circuits,” International Journal of RF and Microwave Computer-Aided Engineering, vol. 26, no. 9, pp. 749–762, 2016. https://doi.org/10.1002/mmce.21028.

I. Angelov, H. Zirath, and N. Rosman, ‘A new empirical nonlinear model for HEMT and MESFET devices’, *IEEE Transactions on Microwave Theory and Techniques*, vol. 40, no. 12, pp. 2258–2266, 1992. DOI: 10.1109/22.179888.

I. Angelov, H. Zirath, and N. Rorsman, ‘A new empirical nonlinear model for HEMT-devices’, in *1992 IEEE MTT-S Microwave Symposium Digest*, IEEE, 1992, pp. 1583–1586. DOI: 10.1109/MWSYM.1992.188320.

I. Angelov, N. Rorsman, J. Stenarson, M. Garcia, and H. Zirath, ‘An empirical table-based FET model’, *IEEE Transactions on Microwave Theory and Techniques*, vol. 47, no. 12, pp. 2350–2357, 1999. DOI: 10.1109/22.808981.

M. Berroth and R. Bosch, “High-frequency equivalent circuit of GaAs FETs for large-signal applications,” IEEE transactions on Microwave Theory and Techniques, vol. 39, no. 2, pp. 224–229, 1991. DOI: 10.1109/22.102964

R. Anholt and S. Swirhun, “Measurement and analysis of GaAs MESFET parasitic capacitances,” IEEE transactions on microwave theory and techniques, vol. 39, no. 7, pp. 1247–1251, 1991. DOI: 10.1109/22.85397.

R. G. Brady, C. H. Oxley, and T. J. Brazil, “An improved small-signal parameter-extraction algorithm for GaN HEMT devices,” IEEE Transactions on Microwave Theory and Techniques, vol. 56, no. 7, pp. 1535–1544, 2008. DOI: 10.1109/TMTT.2008.925212

R. Tayrani, J. E. Gerber, T. Daniel, R. S. Pengelly, and U. L. Rohde, “A new and reliable direct parasitic extraction method for MESFETs and HEMTs,” in 1993 23rd European Microwave Conference, IEEE, 1993, pp. 451–453. DOI: 10.1109/EUMA.1993.336593.

P. Someswaran, “Large Signal Modelling of AlGaN/GaN HEMT for Linearity Prediction,” The Ohio State University, 2015.

Y. Chen et al., “A reliable and efficient small-signal parameter extraction method for GaN HEMTs,” International Journal of Numerical Modelling: Electronic Networks, Devices and Fields, vol. 33, no. 3, p. e2540, 2020. https://doi.org/10.1002/jnm.2540.

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