GaAs MESFET - APPLICATIONS IN DIGITAL LOGIC AND COMPARATIVE ANALYSIS OF THEIR PARAMETERS

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Abstract- The present paper relates to GaAs i.e. Gallium Arsenide MESFET (Metal Semiconductor Field Effect Transistor) centered digital logic employing LTSPICEIV (Linear Technology simulation Program with Integrated circuit emphasis) software. A NAND gate digital logic circuit with physical input constraints is designed with the help of LTSPICEIV software and analysation of its output is being analyzed by the same technology. The devices based on MESFET shows enhanced immunity to noise and its function is better than other devices like transistor. The observation on IDS is going to be performed (Drain to Source current) with respective (Drain to source Voltage) different Vgs (Gate to Source Voltage). By changing the value of Vgs its effect is detected with the help of MS-Excel graphically. Positive output results are gained by simulating NAND digital logic based GaAs MESFET circuit. By analyzing the comparison of Ids with respect to Vds it's noted that the value of Ids is at peak at zero Vgs voltage and its value reduces with more –ve gate voltage.

Index Terms— GaAs, MESFET, Simulation, Model, LTSPICEIV.

I. INTRODUCTION

In previous years manufacturing processes combines several MESFETs into a combined circuit. Now possibility of performing compound analog filtering and signal processing at much high value of frequencies than Silicon devices can. Generally *'MESFET'* is a *'JFET'* made-up in GaAs that develops a Schottky diode as metal-semiconductor gate region. This functions such as junction-gate, and the dissimilarity is a Schottky gate-channel (metal-semiconductor) barrier whereas in JFET there is a gate-channel on junction [1].
JFET and GaAs FET/MESFET exhibit some similar structures, but MESFET proposes superior performance in comparision with that JFET, particularly in the radio frequency amplifiers. MESFETs typically uses compound semiconductor technologies for their construction like SiC, GaAs, InP. These shows faster response but have higher cost than MOSFETs[2].
The 1st MESFET had been industrialized in year 1966 and after a year their tremendously great frequency value RF microwave performance was established. Though, commercial production of high-speed logic circuits by using MESFETs is done since 1984[3].
Typical length of this metal gate transistor lies in between 0.5 to 1.0µm for discrete type transistors but the value for ICs is 0.2µm. The value of width is much higher than length 900 to 1200µm[4]. In the presented paper, length and the width of the gate are 0.5 µ-m and

300 µ-m respectively for relative investigation. A modified model has been developed of GaAs MESFET which is based universal gates then examined, and studied. The graphic diagram of GaAs based NAND Gate is given in Figure 2.1 .By the simulation the structure the circuit is intended i.e LTSPICE. *"LTSPICE stands for Linear Technology Simulation Program with Integrated Circuit Emphasis. It is just a software program in which circuit description is inserted as input and output comes in the form of text data or graphical plots".*

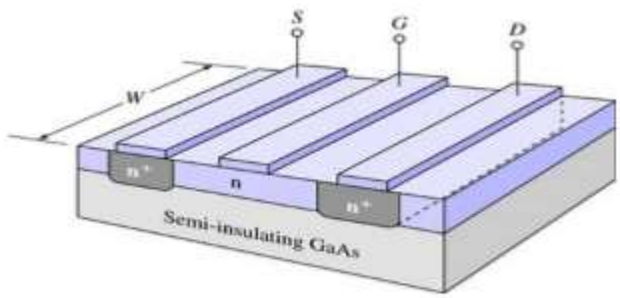

Fig. 1.1: A diagram of gallium arsenide (GaAs) MESFET (metal-semiconductor field-effect transistor) [7].

II. CALCULATIONS

An LTSPICE software has been used for simulating the NAND digital logic circuit based on GaAs MESFET. The designing circuitry of NAND gate is being considered using several tools in the software LTSPICE. Designed circuitry has been represented in fig.2.1.

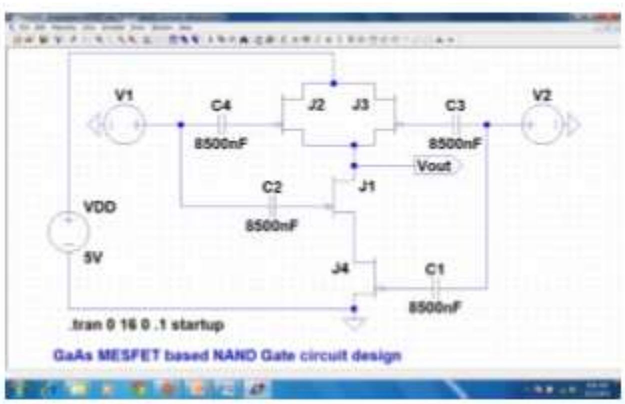

Fig. 2.1: GaAs MESFET based NAND Gate design circuit

The output result of the above design in Figure 2.1 has been detected by using the NAND Gate truth table, and this is given in table 2.1.

Table 2.1: Truth Table of NAND Gate

INPUTS		OUTPUT
Clock Pulse A	Clock Pulse B	Clock Pulse Y Y=A.B
LOW	LOW	HIGH
LOW	HIGH	HIGH
HIGH	LOW	HIGH
HIGH	HIGH	LOW

The analysis is done by the contrast of VI curve of MESFET which is based on GaAs and different readings are (1) Length of Gate = 0.5µ-m (2) Width = 300 µ-m (3) Pinch off voltage = -0.6V and (4) Saturation Current = milli-amperes.

Table 2.2: Readings for V-I characteristics of GaAs based MESFET

Vds (V)	Ids (mA) Vgs = 0.0V	Ids (mA) Vgs = -0.2V	Ids (mA) Vgs = -0.4V	Ids (mA) Vgs = -0.6V
0.2	12	11	10	8
0.4	22.5	21	18.2	15.5
0.65	32	28	25.3	20.1
0.8	39	35.2	29.1	22.3
1	44	37.5	30.5	24.1
1.65	46.2	39.3	31.4	24.9
1.8	47.5	40.2	32.5	25.5
2	48	41.2	33	26
2.2	48.5	41.5	34.3	26.5
2.4	49.8	42.5	34.5	27.4
2.6	50	42.5	34.8	28
2.8	50.5	43	35	29.2
3	50.8	43.5	35.5	29.2
3.4	51	43.9	35.8	29.8
3.6	51.1	44	36	29.9

III. RESULTS

The simulation has been done and result of by simulating NAND Gate in also shown in LTSPICE based on GaAs MESFET. In Figure 3.1 the NAND Gate truth table is given (Table 2.1). The results got from the project and according to those results when the application of appropriate physical input constraints to the circuit then high output is received for low inputs as shown in Fig 3.1 and it is low for the high inputs represented in Fig. 3.1. the output is again high when one of the inputs is high and other one is low shown in Figure 3.2 [5] as the operation of NAND gate is performed. A software named as MS-EXCEL is used for analysing the comparison of V-I characteristics appearance of GaAs MESFET. From Figure 3.3 one can see the outrput. The plotted graph is between Vds & Ids at different values of Vgs. It’s detected that the value of current is at peak while the value of

Vgs is zero volts and when Vgs or gate voltage value becomes -ve, value of current reduces with more –ve value [6]. Semiconductor based capacitor has specifications:

Value of Length: - 151 n-m,

Value of width: - 452 n-m,

Bottom Capacitance value at junction: -00.21nF/m,

Junction Sidewall Capacitance: - 00.51nF/m,

Narrowing due to side etching: -0050nm.

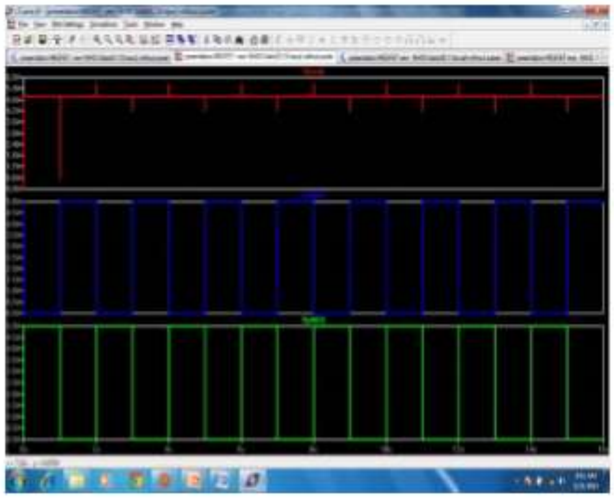

Fig. 3.2: Output waveform of GaAs MESFET based NAND Gate at 01, 10 input

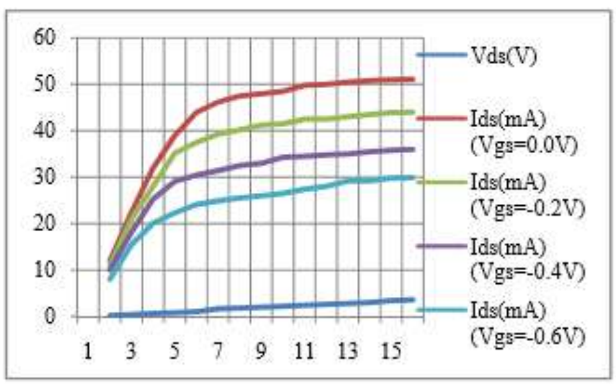

Fig. 3.3: Comparative analysis of Ids w.r.t Vds at varying Vgs.

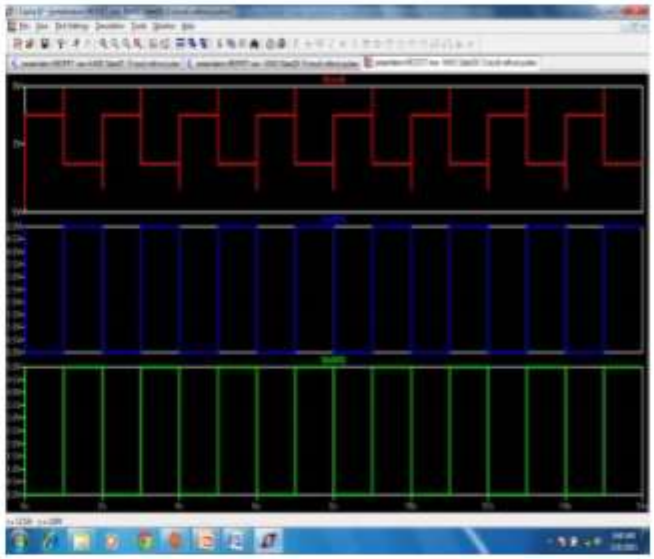

Fig. 3.1: Output waveform of GaAs MESFET based NAND Gate at 00,11 input

IV. CONCLUSION

By the analysation, it has been determined that satisfactory output results are found from the simulation of GaAs MESFET as a NAND Gate. The comparison presented that the value of drain current is extreme at Vgs=0V and supplementary reduction in its value at more –ve voltage of gate.

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