UNIVERSITI TEKNOLOGI MARA

OPTIMIZATION OF DC AND RF PERFORMANCES USING MULTIPLE-GATED HIGH ELECTRON MOBILITY TRANSISTOR (HEMT)

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Thesis submitted in fulfillment of the requirements for the degree of Master of Science

Faculty of Electrical Engineering

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Candidate's Declaration

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is a result of my own work, unless otherwise indicated or acknowledge as referenced work. This topic has not been submitted to any academic or non-academic institution for any other degree or qualification.

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ABSTRACT

This study carried out a detail analysis of the performance of HEMT device with various numbers of gate fingers with respect to their DC and RF performances. The devices were fabricated by a Plessey foundry which adapted a HEMT process with 0.2 µm GaAs technology. A few stages were taken during this study to obtain the desired performance for each device layout. The first was to perform device simulation of different layouts in order to get a preliminary result. This simulation result was used as a reference during the second stage which consisted of actual device measurement. The measurement was done using on-wafer measurement technique within the frequency range from 100 MHz to 40 GHz. The results from these approaches have shown that each device layout exhibited its own characteristics with specific advantages and disadvantages towards the DC and RF performances. The device with higher number of gate fingers has superior advantages in output current performance but exhibited lower cut-off frequency and higher noise compared to the other layouts used in this study. The analysis gave some indications on the weaknesses of a device with higher gate numbers in high frequency circuit design applications. Nevertheless, further research work may also be done especially when involving various material structures, layout types and foundry processes in a HEMT device development.

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CHAPTER 1

INTRODUCTION

The chapter explains the background of the study and the purpose of doing the research. The work carried out focused mainly on the DC and RF performance of GaAs HEMTs. The issues and problems related to existing device technology will be discussed in detail here as well as the solutions.

1.1 Development of Analogue Semiconductor Device

The rapid development of a semiconductor device for analogue telecommunication system is driven by the tight requirement of having a high quality transmitted signal in basic two-way communications. From the basic principle of transmitter and receiver systems, the strength of the desired signal must be controlled in order to maintain the quality of the data available inside the modulated signal. In order to do that, some specific circuit modules such as amplifier, mixer and oscillator which are linearly operated need to be designed properly. However, these sub-systems depend on the electronic component, which is mostly a semiconductor device around which a circuit is built for that purpose. To support the requirement of recent telecommunication systems such as GSM, WLAN, WiFi and WiMax, the development of this device followed a rapid change in the past ten years. This can be seen by the growing number of semiconductor companies capable of producing high performance analogue devices, in conjunction with the drastic changes of the present telecommunication systems.

When the specification for this technology requires a superior and robust performance, there must be some criteria of the device that need to be taken into