STATISTICAL ANALYSIS AND OPTIMIZATION OF 5.8 GHz RF AMPLIFIER

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This report is submitted in partial fulfilment of the requirements for the award of Bachelor of Electronic Engineering (Telecommunication Electronics) With Honours

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Specially dedicated to my beloved parents, family, friends, lecturers and all UTeM colleagues for their support and encouragement.

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ABSTRACT

This thesis presented the work done on the design simulation of a Radio Frequency amplifier. The Exelics EPA018A-70 was chosen over other transistors due to the high efficiency it offers for an amplifier design. Several measurement techniques using Advanced Design System 2005A for simulations and MathCAD for the design calculation were used to verify the performance of the designed amplifier. The built amplifier performed reasonably well for the required frequency band 5.8GHz on the tests of power gain which achieved 18.61 dB, 2.934 dB noise figure, SWR of 1.092 for $VSWR_{in}$ and 2.089 for $VSWR_{out}$, thereby closely matched for the measured readings with the simulated results.

ABSTRAK

Laporan ini membentangkan hasil kerja dalam mereka bentuk secara penyerupaan sebuah penguat frekuensi radio. Transistor EPA018A-70 daripada Exelics dipilih kerana ia mempunyai kadar kecekapan yang tinggi berbanding transistor yang lain untuk rekaan sebuah penguat. Perisian Advanced Design System 2005A digunakan untuk mereka bentuk litar dan pengujian manakala perisian MathCAD digunakan untuk kerja-kerja pengiraan dan mengesahkan hasil rekaan penguat. Rekaan penguat ini menunjukkan prestasi yang baik untuk frekuensi 5.8 GHz di mana gandaan kuasanya mencapai 18.61 dB dengan hingar 2.934 dB, SWR sebanyak 1.092 untuk $VSWR_{in}$ dan 2.089 untuk $VSWR_{out}$, di mana ianya adalah hampir kepada nilai secara teori.

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LIST OF ABBREVIATIONS

ADS	-	Advanced Design System
AlN	-	Aluminium Nitrate
AlGaN/GaN	-	Aluminum Gallium Nitride / Gallium Nitride
BJT	-	Bipolar Junction Transistor
BPF	-	Band Pass Filter
CMOS	-	Complementary Metal Oxide Semiconductor
dB	-	Decibel
DC	-	Direct Current
FET	-	Field Effect Transistor
FSK	-	Frequency Shift Keying
GaAs	-	Gallium Arsenide
HBT	-	Heterojunction Bipolar Transistor
HEMT	-	High Electron Mobility Transistor
IEEE	-	Institute of Electrical and Electronic Engineering
InGaAs	-	Indium Gallium Arsenide
LNA	-	Low Noise Amplifier
MESFET	-	MEtal Semiconductor Field Effect Transistor
MMIC	-	Monolithic Microwave Integrated Circuits
PA	-	Power Amplifier
PAE	-	Power Added Efficiency
RF	-	Radio Frequency
SiC	-	Silicon Carbide

TL	-	Transmission Line
TWPA	-	Travelling-Wave Power Amplifier
UWB	-	Ultra Wide Band
VSWR	-	Voltage Standing Wave Ratio
WLAN	-	Wireless Local Area Network

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

1.1 Project background

Radio Frequency (RF) means any frequency within the electromagnetic spectrum associated with radio wave propagation. When an RF current is supplied to an antenna, an electromagnetic field is created that then is able to propagate through space [1].

Radio Frequency amplifier (RF amplifier) represents one of the basic building blocks of the communication system. There are many types of RF amplifier and every types of RF amplifier have its own characteristic. But the main purpose of all RF amplifier types is quite similar. The purpose of the RF amplifier is to amplify the received signal to acceptable levels of gain thus improving the efficiency of transmission from source to load.

1.2 Project objectives

The main objective of this project is to study the background of a RF amplifier and proposed a suitable RF amplifier unit and optimizes the circuit with overall gain of 20dB with noise figure less than 3dB.

1.3 Problem statements

As we know, the main function of RF amplifier is to amplify the received signal to a certain level of gain. RF amplifier is needed in the communication system because of its function which is to amplify the received signal. The received signal in the receiver antenna is lower than the transmitted signal due to the attenuation and noise in the channel. The RF amplifier used to amplify the information signal in order to have a clearer signal.

The major problem in this project is to design the suitable RF amplifier for the specified requirements. The method used in designing the RF amplifier and matching network also are the crucial part in designing the RF amplifier.

1.4 Scope of work

The scopes of work for this project are limited to the following aspects:

1. Types of amplifier.
   Several types of RF amplifier and its application viewed to understand about the RF amplifier.

2. Types of transistor.

   Types of transistor used in most RF amplifier viewed and its characteristic studied.

3. Matching technique.

   Types of matching technique studied the advantages and disadvantages for every matching technique observed.

4. Specification for circuit and testing.

   The specification for circuit and testing are set based on previous achievement of RF amplifier design.

1.5 Project methodology

Phase 1:

Transistor selection.

Phase 2:

Theoretical analysis of RF amplifier.

Phase 3:

Circuit design and analysis.

Phase 4:

Simulate and optimize the designed RF amplifier

Phase 5:

Compare of result based on theoretical and simulation.

1.6 Report structure

This report divided into 5 chapters. The first chapter gives a brief explanation about RF amplifier and its function in communication systems. It also gives brief explanations about the overall process of project.

The second chapter is about the literature review of the project. Background knowledge of RF amplifier studied in order to understand the basic in RF amplifier design. Other parameter used in the design such as stability, gains, and matching technique are also studied.

The third chapter is about research methodology which explained about method used and process involved in the project.

The fourth chapter is about the result, analysis and discussion. All the data and results that obtained at the end of this project will be documented in this chapter.

The fifth chapter is the conclusion for this project which includes the final design of RF amplifier and its characteristic performance.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

This chapter reviews about the information obtained from findings and any useful sources. Information from the literature is very important as the background of RF amplifier design. Basic principles used in the analysis and design of RF amplifier developed in this chapter.

2.2 RF Amplifier

The power amplifier is the most important and expensive device in the RF block of Wireless LAN system [2]. The design of RF amplifiers involves less emphasis on noise parameters and more emphasis on linearity and inter-modulation, as well as efficiency and thermal considerations. To design a RF amplifier, one must use large-signal S-parameters and be aware of nonlinear effects.

Where careful design of the input matching network is required to realize the full capabilities of low noise amplifiers, in RF amplifiers more emphasis tends to be on

optimizing the output matching network. There are, however, special problems associated with the very low input impedance that can be found in FET power devices, which require special treatment in the input matching network if wideband operation is to be achieved [3].

A key issue for multi-stage amplifiers is the ability to cascade individually designed stages without a requirement for retuning or redesign to account for the characteristic of the driving or following stages. In many cases, the use of balanced amplifiers permits the benefit of 3 dB coupler inter-stages, which direct reflected power to the isolated port rather than the driving stage. As we will see in later, there are special problems of nonlinear oscillations arising from interaction between signal harmonics and modes of the output matching structure [3]. Figure 2.1 below shows the block diagram of an amplifier circuit:

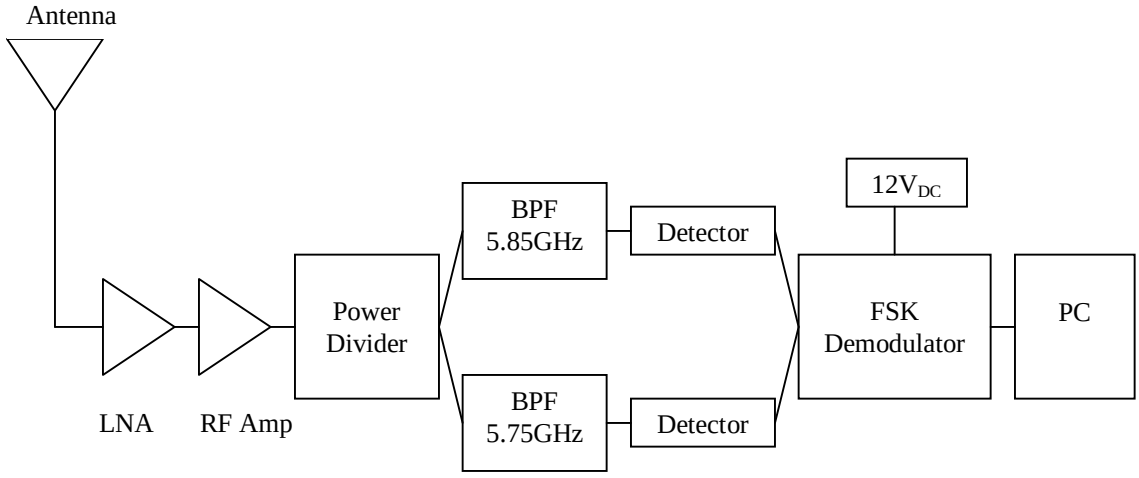

Figure 2.1 RF amplifier in communication system blocks.