STATISTICAL ANALYSIS AND OPTIMIZATION OF A LOW NOISE AMPLIFIER OPERATING AT 5.8 GHz ISM BAND

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"I hereby declare that this report is the result of my own work except for quotes as cited in the references"

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Dedicated especially to my beloved mom, family and friends.

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ABSTRACT

This thesis presents the work done on the design of a low noise amplifier. The purpose of the amplifier is to amplify the received RF path of a Wireless Local Area Network (WLAN). The transistor FHX76LP was chosen over others due to the simplest configuration it offers for an amplifier design. Several measurement techniques are by using Microwave Office and Advanced Design System 2005A (ADS). Calculations are by using MathCad. The amplifier performed reasonably well for the required frequency band which is 5.8 GHz on the tests of power gain which achieved 38.482 dB and noise figure of 0.891 dB, thereby closely matching the measured readings with the simulated results.

ABSTRAK

Tesis ini menunjukkan hasil kerja dalam mereka bentuk sebuah Penguat Rendah Hingar . Fungsi penguat adalah untuk menguatkan penerimaan laluan frekuensi radio dari WLAN. Transistor FHX76LP dipilih kerana ia mempunyai konfigurasi yang paling mudah untuk sesuatu rekaan penguat. Pengukuran dan pengiraan dilakukan dengan menggunakan beberapa perisian yang bersesuaian. Penggunaan perisian Microwave Office dan Advanced Design System 2005A (ADS). Pengiraan pula berdasarkan teori yang menggunakan perisian MathCad. Penguat yang telah direka menunjukkan tahap kebolehan pada frekuensi yang diperlukan iaitu 5.8 GHz apabila diuji pada gandaan kuasanya mencapai 38.482 dB dan kehingaran pada 0.891 dB.

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LIST OF ABBREVIATION

ADS	-	Advanced Design System
AlGaAs	-	Aluminium Gallium Arsenide
BJT	-	Bipolar Junction Transistor
CMOS	-	Complementary Metal Oxide Semiconductor
dB	-	Decibel (Unit)
ESD	-	Electrostatic Discharge
FET	-	Field Effect Transistor
GaAs	-	Gallium Arsenide
HEMT	-	High Electron Mobility Transistor
HFET	-	Heterostructure Field Effect Transistor
IEEE	-	Institute of Electrical and Electronic Engineering
ISM	-	Industrial, Sceintific and Medical
LNA	-	Low noise amplifier
MOSFET	-	Metal–Oxide–Semiconductor Field-Effect Transistor
NF	-	Noise Figure
PCSNIM	-	Power- Constrained Simultaneous Noise and Input Matching

RF	-	Radio Frequency
SiGe	-	Silicon-Germanium
SMT	-	Smart Manufacturing Technology
SNIM	-	Simultaneous Noise and Input Matching
UWB	-	Ultra Wide Band
WiMAX	-	Worldwide Interoperability for Microwave Access
WLAN	-	Wireless Local Area Network

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CHAPTER I

INTRODUCTION

1.1 Project Background

The low-noise amplifier (LNA) is a special type of electronic amplifier or amplifier used in communication systems to amplify very weak signals captured by an antenna. It is often located very close to the antenna as in Figure 1.1 below. If the LNA is located close to the antenna, then losses in the feed line become less critical. It is a key component, which is placed at the front-end of a radio receiver circuit. The overall noise figure of the receiver front-end is dominated by the first few stages [1].

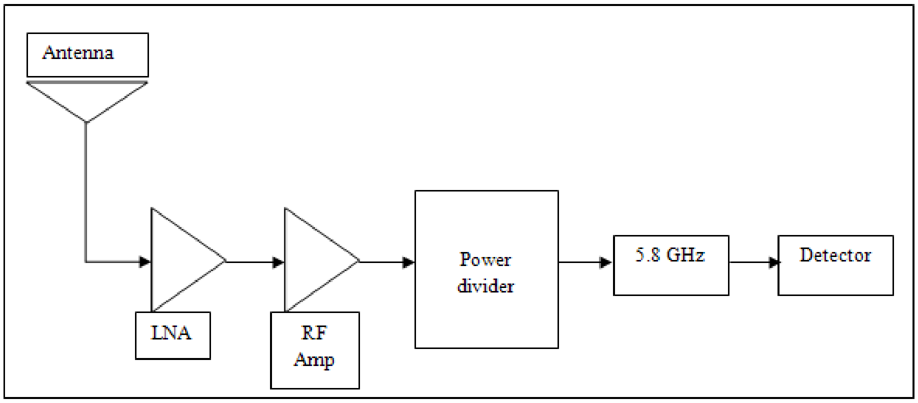

Figure 1.1 Front-end receiver block diagram

Low noise amplifiers represent one of the basic building blocks of the communication system. The purpose of the LNA is to amplify the received signal to acceptable levels while minimizing the noise it adds. This low noise amplifier is use for front end receiver. The reduction in the signal due to losses during transmission, reception and power dissipation in circuit components must be compensated by using a device to provide sufficient gain for the receiver circuit.

1.2 Objective

The objective of this project is to design a low noise amplifier, simulate and optimize the circuit of a low noise amplifier which is operating at 5.8 GHz ISM band with overall gain of at least 40 dB and noise figure less than 3 dB with the input and output return loss is 10 dB.

1.3 Problem Statement

Other Low Noise Amplifier that using FET has the gain less than 30 dB. So, in this project, the aim is to design a low noise amplifier that has higher gain and lower noise. The gain to be targeted is 40 dB and the noise figure is less than 3 dB to get the optimum value of signal received.

1.4 Scope of Project

Basically, the scope of this project is divided into few phases. The first phase is to understand the background of a low noise amplifier and proposed a suitable low noise amplifier unit. In this phase, a transistor is chosen for designing the LNA. The reason why the transistor is chosen is stated in Chapter III.

The next phase is the theoretical part. In theoretical part, calculations are used to measure all of the parameters in order to design the amplifier. Before that, all the formulas and parameters are studied. Some of the calculations are by using Microwave Office software which is determining the s-parameter for 5.8 GHz which is not stated in the datasheet. The datasheet only stated the round value from 1 GHz to 20 GHz. Another software used for calculations in this design is MathCad software. Mathcad is a math tool that combines a computational engine, accessed through conventional math notation with a full-featured word processor and graphing tolls. This software is used to calculate the stability; the power gain, available gain and transducer power gain before matching; and for matching which are mismatch value and noise figure.

After finished the calculations part, simulations and optimizations are done by using appropriate software such as Ansoft Designer and also Microwave Office software. Finally, the results are compared based on theoretical and simulation.

1.5 Research Methodology

Phase 1:

Study and understand the background of low noise amplifier, collect information for any software that could be used for all the calculation, simulation, optimization, and comparing of the result.

Phase 2:

Theoretical analysis of low noise amplifier which is stability, gain, and noise figure based on requirements and transistor model selected.

Phase 3:

Simulation and optimization of the low noise amplifier design.

Phase 4:

Comparing of the result based on theoretical and simulation.

1.6 Report Structure

This report discusses the theoretical analysis, simulations and optimization the design of a low noise amplifier operating at 5.8 GHz ISM band. Consist of five chapters; the report will cover all the matter that should be discussed in designing the project.

Chapter I give the brief information about the introduction of designing the LNA, what should be done and the software used in the design. It also includes the background of project, objective to achieve from this project, problem statement, scope of work and also project methodology.

Chapter II is about the literature review. Literature review is more about the theory. The theory in designing the circuit, how stability is determined, gain and also noise figure.

Chapter III tells about research methodology. Methodology is very important aspect in any work that wanted to be done. Work will be systematic and can be completed in time if we already plan what we wanted to do.

Chapter IV includes the results and discussion of the project. The result in here is the calculation made from the s-parameter until the value of noise figure that are get.

Chapter V is the conclusion and suggestion of the project. Suggestion is important to make sure the project can achieve target in other way than it is on this project.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

As we know, the LNA is the first block in most receiver front ends. Its job is to amplify the weak signal while introducing a minimum amount of noise to the signal [1].

2.2 Frequency

Recently, wireless LAN system have been developed for the C-band (4~8 GHz) frequency. Proposals for wireless data system in the C band range such as 5.8 GHz (Wireless LAN for U.S.A) and 5.2 GHz (Hiper LAN for Europe) have been submitted. The license-free 5.8 GHz frequency band provides wider spectrum frequency. Furthermore, investigations showed that 5 GHz applications in narrow surroundings can provide better performance than 2.4 GHz applications as the shorter wave length