# PARAMETRIC STUDY ON MATCHING NETWORK AT LNA 6GHZ

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**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

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**This Report Is Submitted In Partial Fulfillment of Requirement for the Bachelor Degree of Electronic Engineering (Wireless Communication) With Honours**

**Fakulti Kejuruteraan Elektronik Dan Kejuruteraan Komputer**
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## DECLARATION

I hereby, declared this report entitled 'Parametric Study on Matching Network at LNA 6GHz' is the results of my own research except as cited in references.

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"I hereby declare that I have read this report and in my opinion this report is sufficient in terms of the scope and quality for the award of Bachelor of Electronic Engineering (Wireless Communication) With Honours"

Signature :

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Date : 17/6/15

Special dedication to my family, my supervisor Dr. Mohd Azlishah bin Othman and to all my dearest friends.

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# ABSTRACT

Wideband amplifier design remains one of the most challenging portions in the communication system. The conventional low noise amplifier operates on a single band, in which it is simpler to plan the enhancer to meet the whole indicated objective. Conventional routines for tuning and tweaking will require more repetitive and long time to cover the wider frequency range, accordingly rendering the method to be impractical. Therefore, a more particular specialized methodology must be used to help the designer to better design the amplifier.

This paper represents the amplifier requirements in wideband application and proposed a structured practical design approach which uses the feedback topology by utilizing Advanced Design System (ADS) simulations in optimizing the amplifier to meet all the obliged specs. The purpose of the amplifier is to amplify the received RF path. The design methodology required the analysis of the transistor stability and proper matching network selection. The design of an LNA in Radio Frequency (RF) circuits requires the trade-off of many importance characteristics such as gain, noise figure (NF), stability.

This situation forces designers to make choices in the design of RF circuits. This was the main reason why the ATF54143 from Avago Technologies was chosen over others due to the simplest configuration it offers for an amplifier design. Several measurement techniques using design tool Advanced Design System (ADS) for simulations where the noise circles and available gain circles are the tools that give the most guidance on the design tradeoffs, while FR4 strip board is used for fabrication purposed and the Network Analyzer for the practical testing of the amplifier were used to verify the performance of the designed amplifier.

# ABSTRAK

Reka bentuk penguat jalur lebar adalah salah satu bahagian yang paling mencabar dalam sistem komunikasi. Konvensional penguat bunyi yang rendah beroperasi pada jalur tunggal, di mana ia adalah lebih mudah untuk merancang penambah untuk memenuhi matlamat yang diinginkan. Rutin konvensional untuk penalaan biasanya akan mengambil masa yang lebih lama dan berulang-ulang untuk meliputi julat frekuensi yang lebih luas , dengan itu menjadikan kaedah yang digunakan ini kurang sesuai dan tidak praktikal. Oleh itu, kaedah yang khusus harus digunakan untuk membantu pereka untuk mereka bentuk penguat yang lebih baik.

Kertas kerja ini membentangkan kepentingan penguat dalam aplikasi jalur lebar dan mencadangkan satu pendekatan reka bentuk praktikal berstruktur yang menggunakan topologi maklum balas dengan menggunakan simulasi Sistem Design Advanced ( ADS ) dalam mengoptimumkan penguat supaya memenuhi semua ciri-ciri yang diinginkan . Kegunaan penguat adalah untuk menguatkan RF signal yang diterima. Reka bentuk penguat bunyi rendah dalam Frekuensi Radio litar (RF ) memerlukan keseimbangan ciri-ciri kepentingan ramai seperti dapatan , bunyi ( NF ) dan kestabilan.

Keadaan ini memaksa pereka untuk membuat pilihan dalam reka bentuk litar RF. Ini adalah sebab utama mengapa ATF54143 dari Avago Technologies telah dipilih dalam projek in selain pemasangan yang mudah. bentuk fi er. Beberapa teknik pengukuran menggunakan perisian (ADS) bagi simulasi di mana bunyi dan dapatan boleh didapati. Manakala FR4 papan jalur digunakan untuk fabrikasi.

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# CHAPTER 1

# INTRODUCTION

## 1.1 Project Background

Low Noise Amplifier (LNA) represent one of the basic building blocks of the communication system. In figure 1.1, LNA is placed between RF Filter 1 and RF Filter 2. The week signal that came from BPF1 will be amplify before it can be process. The basic function of LNA is to provide amplifying the signal while adding a minimum amount of noise to the signal[1]. In addition, Low Noise Amplifier (LNA) plays an important role in the receiver designs because it has major effect on the noise performance of the overall system.

Another characteristics from the LNA consists of low noise figure, reasonable gain and stability over the designated frequency band without oscillating even though running on very low power. For large signal, LNA amplifies the signal without adding any kind of distortions.

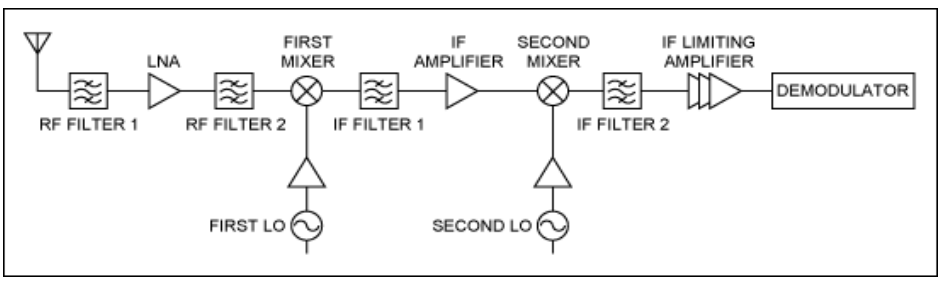


Figure 1.1: Block diagram of a receiver

In this project, ATF-54143 transistor from Avago technologies is used. This transistor is choosen because it high dynamic range, low noise transistor and it can execute with low voltage supplied[2]. Furthemore, this transistor meet the requirement for this project design which is the design is at 6GHz. The LNA design in this report is performed with a systematic procedure and simulated by Advanced Design System (ADS2011)

This project deal with a high performance wideband low noise amplifier which operates for 6GHz is presented. This LNA needs to provide a constant gain, low noise high linearity and unconditionally stable to make sure design meet the standard specification.

Before start designing, the design requirement is set in order to ensure our LNA designed can achieve the target. The design specifications for this project were as follows:

Table 1.1: LNA Design Specification

| **Parameter** | **Specs** |
|---|---|
| Operating frequency | 6 GHz |
| Gain | > 5 dB |
| Noise Figure | < 3 dB |
| Return loss for source | > -10 dB |
| Power supply | 3V |

## 1.2 Project Objective

LNA is used to amplify the low signal and at the same time reduce noise. It usually located at the front-end of receiver. The objective of this project are listed below:

- To study the gain, return loss, noise and stability of LNA which operates at 6GHz.
- To do the parametric study on matching network at LNA 6GHz.
- To design a high frequency LNA circuit by using Advance Design System (ADS) software.

## 1.3 Scope of Project

Scope of this project is divided into four parts:

a) Literature review

- Study on the conventional design of low noise amplifier (6GHz).

b) Design and simulation

- Design LNA circuit with different types of matching network.
- Simulate the LNA circuit using ADS in order to get the desired gain, return loss, noise and stability.

c) Fabrication

- Fabricate the design circuit using FR4 board.

d) Test analysis and measurement

- Get a stable, high gain with desired return loss and low noise for a LNA 6GHz

## 1.4 Problem Statement

The signal will face interference when signal travels and there are some noise will occur in the signal when signal arrived at the receiver. The noise that occurs is an unwanted noise because it can affect the information carried by the signal.

The best way to reduce the noise occurs is by placed the LNA at the RF front end of receiver. The LNA is a simpler, space saving, excellent linearity, low current consumption and more efficient option which allows the receiver chain to have variable gain.

Week electrical signal is captured by the amplifier which is the closest to the antenna in the receiver chain. Simultaneously, strong interfering signal may be present. For this reason, these low noise amplifiers primarily establish the system noise figure and inter-modulation behavior of the overall receiver. The common goals are therefore to minimize the system noise figure, provide enough gain with sufficient linearity. The second problem is, small signal gain is essential in producing gain but will result a small gain value.

## 1.5 Project Methodology

### i) Transistor selection

- ATF 54143
- Frequency range: 450MHz to 6GHz
- Reason: To get the minimum acceptable gain value by putting 6GHz as the highest boundary.

### ii) Biasing network

- Biasing networks are needed to set appropriate operating conditions for active devices (transistor-ATF54143).
- Passive bias, voltage divider circuit

**iii) Matching network**


Figure 1.2: Matching network block diagram

Matching:
Placed between load impedance and transmission line. [7]

When load match: [7]
Maximum power delivered to the line.
The power loss is minimized.

**iv) Check for gain, noise figure, stability and return loss**

- Gain ≥5 dB
- Noise <3 dB
- Stability, K >1
- Return loss > -10

## 1.6 Summary of Work

The Gantt chart below shows the works that had been implemented in the first and second semester. Refer to Appendix A.

## 1.7 Thesis Outline

This thesis consists of five. Chapter 1 of this report is about the introduction of the project. Brief introduction where problem statement, objective, scope of project, project methodology and summary of work are presented in this chapter.

Chapter 2 cover the literature review of hardware and software of LNA design. For this purpose, basic of RF, introduction of LNA and LNA design process is explained.

Chapter 3 gives an overview for design methodology with the technologies and tools used in developing the application. Also explained the LNA design process which is the transistor selection, stability checking, DC biasing, matching networks, simulation and layout design.

For Chapter 4, it will cover the results obtained from the simulation and fabrication process. All the data obtained will be analyzed and discussion regarding the results will be made.

Lastly in chapter 5 will cover the conclusion of overall project. Suggestions to improve this project are also being presented in the same chapter.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

Nowadays, the growing demand in high requirement wireless technology had raised the development of LNA. The main purpose of LNA is to amplify the low signal and at the same time, not adding any noise. So, no noise is adding while it amplifies the signal, hence eliminating channel interference. The main characteristic that have to consider while design LNA are stability, power gain, bandwidth, noise figure, VSWR and DC requirement. [3]

LNA usually designed by using BJT, GaAs FET, CMOS, PHMET and MESFET type of transistors. Such sensitivity analysis of LNA is very beneficial for making appropriate design trade-off. The high requirement of wireless communication has increase the difficulties for LNA designed which has higher capability in providing higher gains, better input sensitivity and minimize noise level[4].

Before start this project, a lot of research is done in order to know a basic of LNA designing. Internet and RF books are the main sources to get all the information. Research is more focus on how to design the LNA. First of all, datasheet transistor are

reviewed to understand the characteristics and to identified which transistor is the best to be use.

The s2p file that is provided by the transistor manufacturer is used to simulate the S-parameter characteristic and the biasing information by using Advanced Designed System (ADS). By done this simulation, the better understanding on the performance of the transistor will be get. A BJT is a good choice for LNA design because it have a higher gain with a low noise figure.

## 2.2 Design Consideration

Important criteria that need to be consider in designing LNA are stability, noise figure, power gain, VWSR and DC biasing. To bias the transistor, LNA must have DC biasing circuit and also must have input and output matching network to achieve optimum power transfer in the circuit. LNA operate in class A mode. By referring to data sheet, the biasing point for the LNA should have high gain because high gain will amplify the signal and separated the noise from the signal [4]. In addition, LNA must have low noise figure, linear, good input and output matching and unconditionally stable at the lowest current drain from the supply. The transistor must be select correctly to make sure it can meet most of these conditions. Feedback arrangement can give a low noise figure and good output match [3].

Unconditionally stable means that amplifier does not oscillate. There are a trade-off between stability and gain because of either shunt or series resistive loading of the collector. There is an important limitation to observe variations throughout VSWR parameters. It is not possible in order to plot input and output of VSWR circles concurrently. Any Plot involving (Input / Output) VSWR implies that one of many network is match which is to be reference to observe variance within the other aspect from the network.