DESIGN OF LOW NOISE AMPLIFIER FOR RADAR APPLICATION

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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

Faculty of Electronics and Computer Engineering
Universiti Teknikal Malaysia Melaka

JUNE 2015

UNIVERSTI TEKNIKAL MALAYSIA MELAKA

FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN

PROJEK SARJANA MUDA II

Tajuk Projek : DESIGN OF LOW NOISE AMPLIFIER FOR RADAR APPLICATION

Sesi Pengajian : 1 4 / 1 5

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Date : 17/6/15

For the most beloved and supporting parents,

HAJI KONANG BIN HAJI SADIT

HAJAH RANI BINTI JEMAIN

Dedicated, in thankful appreciation for the support, encouragement, love and understanding.

ACKNOWLEDGEMENT

Alhamdulillah, all praise to Allah SWT, God Almighty, Most Merciful for His guidance, blessing and by His will the project is successfully finished. A million thanks to my beloved family, who gives me encouragement and loved throughout the project. Without the encouragement and loved, the project will not be succeeded.

I would like to personally and sincerely express my gratitude to my supervisor, Mr. Azahari bin Salleh who has been of outmost help and patience. From the first I started my project designed until the end of my PSM II, he has been my source of motivation, inspiration, and my guiding light. All the input towards the practical has tremendously benefited me in various aspects.

I would like to take this chance to express my thanks to the management of Faculty Electronic and Computer Engineering (FKEKK), UTeM, for give me the opportunity to use all the facilities in FKEKK. Without the kind cooperation from all the people, this project would not be able to be completed in such as smooth manner.

Last but not least I would like to thank all my friends and all people who have been extremely supportive and helped me intentionally or unintentionally throughout the duration of the entire practical and helping me to complete my final year project report.

Thank You Very Much!

ABSTRACT

Wireless communication generally considered to be a branch of communications. One of the wireless technology and communication application is radar. The receiver Radio Detection And Ranging System (RADAR) generally consists of a Low noise amplifier (LNA), and down converting mixers. LNA is a very important element in Radar systems, which placed at the front end of a radio receiver circuit. The LNA main function is to provide the first signal of amplification and reduce the noise in the received signal. Without the LNA the signal that enters the system will be very week and fill with noise. This will make harder for the system to read the signal. A LNA is design for radar application. In this project, the design of a 9.1 GHz Low Noise Amplifier of radar receiver that used in the Navigation is presented. The objective of this project is to design and simulate LNA for 9.1 GHz (X-Band). Transistor ATF-35143 Low Noise Pseudomorphic HEMT from Avago Technology was used to design the LNA. The ADS will be using for this project in simulation part and the LNA was design from two-port network transistor starting from scratch, input and output matching and DC biasing to design a single stage LNA. The last step in designing this project is design two-stage LNA by using cascaded two-stage LNA method which is to keep the cost of the circuit in low prices and the high performance. This design were able to fulfil the design goals of noise figure 2.323 dB, gain15.816 dB.

ABSTRAK

Komunikasi tanpa wayar secara amnya dianggap sebagai satu cabang komunikasi. Salah satu aplikasi teknologi tanpa wayar dan komunikasi adalah radar. Sistem radar penerima secara umumnya terdiri daripada penguat hingar rendah (LNA). LNA adalah elemen yang sangat penting dalam sistem radar, yang dimana diletakkan di bahagian hadapan penerima radio. Fungsi utama LNA adalah membekalkan pembesaran semula isyarat yang pertama dan mengurangkan tahap hingar pada isyarat yang telah diterima. Tanpa LNA isyarat yang masuk akan lemah dan dipenuhi dengan hingar. Ini menyukarkan sistem untuk membaca isyarat. LNA direka bentuk untuk kegunaan RADAR. Dalam projek ini, reka bentuk isyarat penguat bunyi yang rendah frekuensi 9.1 GHz untuk kegunaan Navigasi dibentangkan. Objektif projek ini adalah untuk mereka bentuk dan membuat simulasi penguat hingar rendah 9.1 GHz (X-Malar). Transistor ATF-35143 mempunyai angka hingar yang rendah *Pseudomorphic HEMT* dari Avago Teknologi akan digunakan untuk mereka bentuk LNA kerana ia memenuhi spesifikasi. Simulasi untuk projek ini menggunakan ADS dan bermula dari awal LNA akan direka bentuk daripada dua-pin transistor rangkaian, arus terus kepincangan untuk mereka bentuk tahap pertama LNA. Langkah yang terakhir untuk mereka bentuk projek ini adalah tahap kedua LNA yang menggunakan kaedah tahap kedua *cascaded* dimana untuk mengurangkan kos litar pada harga yang rendah dan berprestasi tinggi. Rekaan LNA ini berupaya memenuhi matlamat reka bentuk LNA dengan angka hingar paling rendah 2.323 dB, gandaan sebanyak15.816 dB.

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SYMBOL	DEFINITION
BS	Base Station
CS	Central Station
HEMT	Heterojunction Bipolar Transistor
PHEMT	Pseudomorphic Heterojunction Bipolar Transistor
FET	Field Effect Transistor
IF	Intermediate Frequency
IL	Insertion Loss
LNA	Low Noise Amplifier
NF	Noise Figure
PA	Power Amplifier
RF	Radio Frequency
VSWR	Voltage Standing Wave Ratio
RADAR	Radio Detection And Ranging

LIST OF SYMBOLS

SYMBOL	DEFINITION
C	Capacitor
dB	Decibel
f	Frequency
g	Element Values
G	Giga
H	Height
Hz	Hertz
I	Current
K	Rollet's Stability Factor
Km	Kilometre
L	Inductance
m	Meter
mA	Miliampere
mm	Millimetre

mW	Miliwatt
nM	Nanometer
π	Pi
P	Power
R	Resistance
S	Scattering
V	Voltage
Ω	Ohm
Y	Admittance
Z	Impedance
δ	Fractional Bandwidth
εr	Relative Dielectric Constant
λ	Wavelength

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CHAPTER I

INTRODUCTION

1.1 Project Background

It is an unquestionable fact that wireless technology and communication has, and keeps, changing our everyday lives. Wireless communication is the transfer of information over a distance without the use of electrical conductors or cable. Wireless communication generally considered to be a branch of communications. One of the wireless technology and communication application is radar. Today, radar systems exist for a variety of applications from weather observation to guidance systems and law enforcement. In its simplest form, a radar system consists of three subsystems, a transmitter, a receiver, and an antenna system. Figure 1.1 shown the Radio Detection and Ranging System.

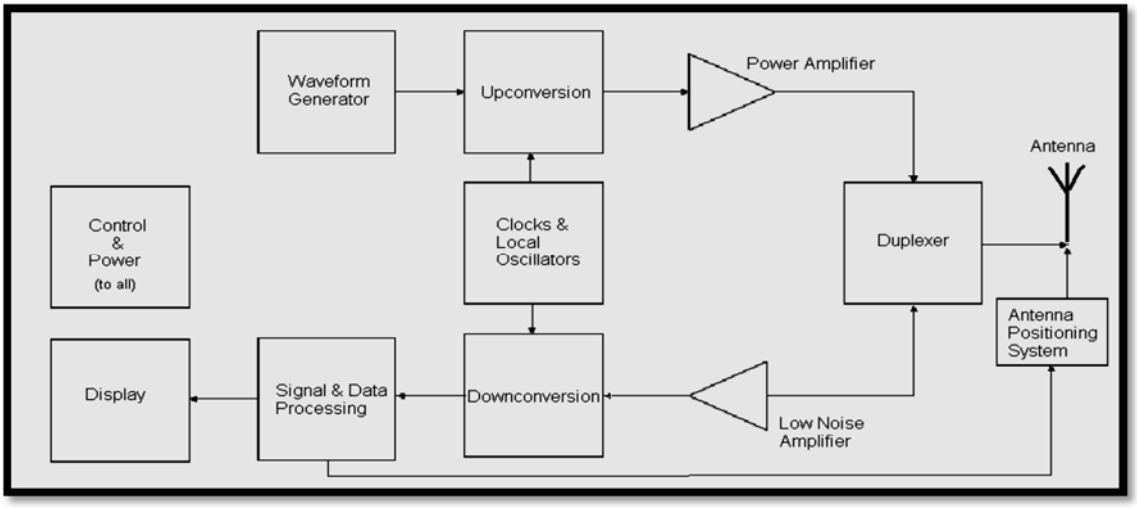

Figure 1.1: Radio Detection And Ranging System

Radar can be used for wireless networking in much the same way as the more common broadband. The function of the radar receiver is to detect wanted echo signals in the presence of noise, clutter, and interference. The word radar is a condensation derived from the phrase Radio Detection and Ranging and applies to electronic equipment designed for detecting and tracking objects (targets) at considerable distances.

The receiver radar system generally consists of a Low Noise Amplifier (LNA), and down converting mixers. LNA is a very important element in Radar systems, which placed at the front end of a radio receiver circuit. When using a LNA in this systems, the noise in the signal can be reduced and the signal amplified by the noise figure and gain of the LNA. Without LNA, the signal cannot be identified or read by the system because of the noise inside the signal. [1]

The purpose of a LNA is to boost the desired signal power while adding as little noise and distortion as possible so that retrieval of this signal is possible in the later stages in the system. There are a few different kinds of amplifiers that can provide

suitably low noise figures. The lower the noise figure of the receiver, the less need there is for be transmitter power for the same performance.

The X-Band is a segment of the microwave radio region of the electromagnetic spectrum. X-Band is a popular frequency range because the shorter wave length at these frequencies allows for high resolution, but the relatively low atmospheric attenuation enables longer range systems. The high sensitivity X-band 9.1 GHz receiver is an important device for wireless communication application such as radar and satellite communication. With the increasing acceptance of X-Band as a substitute for the existing wireline infrastructure in the last mile, people are now designing and testing using wireless broadband.

Base on objective of this project which is to design and simulate Low Noise Amplifier for 9.1 GHz for X-Band radar application, it is suitable for military, civil and government institutions for weather monitoring. For the simulation of transistor, single stage and two-stage LNA design using the Advance Device System ADS, Agilent Technologies. In order to keep the cost of the circuit in low prices and the performance high, this LNA design a two-stage LNA which is in cascaded design method. [2]

1.2 Problem Statement

Design the LNA by using single stage face problem in term of high cost of the LNA chip, and also all of component further increase the cost of production. By designing the two-stage, the problem can solve in order to address the low cost constrains of the LNA chip and focused on limiting the amplification stages in two. [1].

If only design the single stage of LNA, LNA will face problem in terms of low noise figure response and gain that produce. But, by designing the two-stage LNA can give a better performance of LNA which is can decreasing the noise figure response and can increasing the gain..

One of the important part in designing LNA is output and input matching. This part involved two method which is simulation in ADS and calculation in smith chart. If the wrong data and value that we get from datasheet and also in smith chart during the calculations it affect overall LNA design and performance. So, need to be careful while nominated and picked data and also in calculations to get the best and possible results.

1.3 Objective

The most important components in Radar systems is LNA which is usually located at the front-end of a receiver to reduce noise. The objective of the project is to design and simulate Low Noise Amplifier for X-Band Radar application for frequency 9.1 GHz.

1.4 Scope of Project

- The scope of works this project is design in X-Band 9.1 GHz for their frequency.
- Analysis the design, measurement and calculation result can be done in term of S-parameter, stability, gain and the noise figure, DC Bias and input and output impedance matching.

- The software used is ADS will be used for the simulation of transistor and LNA.

1.5 Thesis Outline

Generally, the report will consist of five chapters which are; Chapter 1: Introduction, Chapter 2: Low Noise Amplifier (LNA), Chapter 3: Research Methodology, Chapter 4: Results and Analysis and Chapter 5: Conclusion and Future works.

Chapter 2 is about literature review of low noise amplifier especially on the parameter and the design techniques used in the design procedure. Basic theory of LNA will also be covered in this chapter.

Chapter 3 which is the research methodology will cover on the related methodologies applied in the project. The steps on designing a LNA starting from choosing a transistor and all the calculation involved in order to design the LNA and obtain the simulation result will be discussed in this chapter.

Chapter 4 is discuss about the results analysis based on the comparison of the calculation, through simulation the parameters of transistor can be find which are S-parameter, stability, stability circle, gain, and noise figure. The results of design LNA which are the input and output matching together with DC biasing will be discuss in this part. The design techniques to design a LNA and the comparison that is found in the simulation will also be shown in this chapter.

Lastly, chapter 5 represents the conclusion and future plan of this project. In the conclusion of this project, the summary results and the best design technique that are chosen from comparison will be stated. The future works suggestions of this project will discuss on what are the next steps that can be done.