DESIGN LOW NOISE AMPLIFIER FOR GPS APPLICATION

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Tajuk Projek : Design of Low Noise Amplifier for GPS application

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For the most beloved and supporting parents,

MOHAMAD BIN ABU
MAIMUNAH BTE MINHAT

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

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ABSTRACT

The low noise amplifier (LNA) is a special type of electronic amplifier used in communication systems which amplifies very weak signals captured by an antenna. This is frequently used in microwave or high radio frequency (RF) systems such as mobile hand phone, global positioning system (GPS) or even the large communicating antenna. In this project, the LNA was design for GPS application which is the frequency operating at 1.575GHz. To be able to detect weak signals, the receiving system must maintain a noise level that is lower than the received signal. When using a low noise amplifier, noise is reduced by the gain by the amplifier while the noise of the amplifier is injected directly into the received signal. In this project, the design of microwave transistor amplifiers using the small signal S-parameters was studied to develop the LNA. S-parameters are a valuable aid both for collecting data for a transistor and then using the data to predict performance and design an amplifier circuit. The Smith chart is an easy and practical tool used to designing matching circuits meanwhile the micro-strip lines can perform the impedance conjugate matching. The Microwave Office Software (AWR) was used to simulate the design. In this project, several types of matching were design to match the load. The lumped element, quarter wave and single stub matching are use in this project. From the results obtained, this project could be improved by learning the technique of micro-strip lines fabrication.

ABSTRAK

Pembesar rendah hingar merupakan salah satu pembesar elektronik yang digunakan di dalam sistem telekomunikasi untuk membesarkan isyarat yang amat lemah yang diterima oleh antena. Pembesar ini biasa digunakan di dalam sistem-sistem gelombang mikro mahupun frekuensi radio tinggi seperti pada telefon bimbit, sistem kedudukan sejagat (GPS) mahupun antena komunikasi yang besar. Di dalam projek ini, satu pembesar hingar rendah telah direka dengan mengaplikasikan kehendak GPS yang beroperasi pada frekuensi 1.575GHz. Keadaan asal rendah hingar bagi pembesar rendah hingar merupakan ciri kritikal bagi sistem penerima. Ketika menggunakan pembesar hingar rendah, hingar dikurangkan oleh gandaan disebabkan pembesar sementara hingar daripada pembesar disuntik terus kedalam isyarat yang diterima. Projek ini, rekabentuk bagi pembesar transistor gelombang mikro dipelajari untuk membangunkan pembesar rendah hingar. S-parameters merupakan alatbantu yang membantu mengumpul data untuk transistor dan dengan menggunakan data tersebut untuk menjangkakan prestasi dan rekabentuk litar pembesar. Carta Smith pula merupakan alatbantu yang mudah. Beberapa rekabentuk litar pembesar telah di reka dengan menggunakan pengisian *Microwave Office* (AWR). Beberapa jenis litar pembesar rendah hingar telah direka untuk yang menepati keperluan GPS. Keputusan yang terhasil daripada projek ini memberi petunjuk dimana pembaikan dapat dipertingkatkan dengan mempelajari teknik pembuatan garis jalur-mikro.

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LIST OF ABBREVIATIONS

AGC	–	Automatic Gain Control
AWR	–	Microwave Office
BJT	–	Bipolar Junction Transistor
CDMA	–	Code Division Multiplex Access
DC	–	Direct Current
DS-SS	–	Direct sequence spread spectrum
GPS	–	Global positioning system
IF	–	Intermediate frequency
LNA	–	Low Noise Amplifier
MLIN	–	Microstrip length
MSUB	–	Microstrip Substrate
RF	–	Radio Frequency
Sige	–	Silicon Germanium
SNR	–	Signal-noise-ratio
S-parameter	–	Scattering Parameter

LIST OF SYMBOLS

Z_L	-	Impedance load
Z_S	-	Impedance source
C	-	Capacitor
L	-	Inductor
Z_o	-	Characteristic Impedance 50Ω
Y	-	Admittance
G	-	Giga
dB	-	Decibel
C	-	Capacitor
L	-	Inductor
Mm	-	Millimeter
Hz	-	Hertz
mA	-	Miliampere
Ω	-	Ohms
V	-	Voltan
nH	-	Nano Henry
µF	-	micro Farad
λ	-	Wavelength
P	-	Power
ℓ	-	Length of the MLIN

LIST OF APPENDIXS

CHAPTER 1

INTRODUCTION

This chapter is discusses about the background of the project, problem statement, objective, scope of work and thesis outline.

1.1 Project Background

Global Positioning System (GPS) is a satellite system based on navigation system, which provides navigational information, such as the absolute position, absolute velocity and time information for customers. GPS applications are increased dramatically in the navigation and location service market.

The GPS signal is broadcast at two frequencies: a primary signal at 1.575 GHz (L1 band) and a secondary broadcast at 1.2276 GHz (L2 band). At each GPS frequency, two different direct sequence-spread spectrum (DS–SS) modulations can potentially be present at the same time, each using its own spreading code which are the coarse acquisition code (C/A) code which is the code for civil user, and the protected code (P) code which is a code for military. In radio frequency (RF) front-end devices, the RF signals received from the antenna are amplified by Low Noise Amplifier (LNA) and

then down converted by the mixer to be low frequency signals. For this project just focus a primary signal at 1.575 GHz (L1 band).

The LNA is usually the first block of the receiver after the antenna. As the receiver is required to detect a low power signal, a LNA with extremely low noise figure (≤2.5dB) is required. In addition, the LNA must exhibit a large gain (10 dB to 20 dB) to suppress noise from the subsequent. The design is based on a selection of transistor with S-parameter, matching network, direct current (DC) biasing and stability performance. In LNA design, the most important factors are low noise figure, moderate gain, matching and stability.

1.2 Problem statement

The signal will face interference when signal travels wirelessly and when the signal arrives at the receiver, it has some noise in the signal. For the GPS receiver, that noise is not necessary because it will affect the information that was carried by the signal. Because GPS is the unique requirements, using LNA at the RF front end of receiver is the best way to reduce the noise beside to ensure system efficiency and data accuracy. The LNA is a simpler, space saving, excellent linearity, low current consumption and more efficient solution which allows the receiver chain to have variable gain.

Signal amplification is a fundamental function in all communications systems. Amplifiers in the receiving chain that are closest to the antenna receive a week electrical signal. Simultaneously, strong interfering signal may be present. Hence, these low noise amplifiers mainly determine 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.

Noise from the environment is unavoidable; this sets the lowest signal level that can be detected by a receiver. When noise and a desired signal are applied to the input of a 'noiseless' network (an amplifier), both noise and signal power will be attenuated or amplified by the same factor, thus SNR at the input and output of the network similar. If the network is noisy, SNR_{out} will be larger than SNR_{in}, since there is additional noise power at the output, those that produced by the network itself. Thus, LNA is introduced at the front-end of the receiver to minimize the problem.

The LNA is a special type of electronic amplifier used in wireless communication systems which amplifies very weak signal captured by an antenna. This is frequently used in microwave systems like GPS. When using a LNA, noise is reduced with the gain by the amplifier while the noise of the amplifier is injected directly into the received signal. LNA is usually used as the first stage amplifier for a receiving circuit. Since the signal from the antenna is very weak, the LNA amplifies the signal without contributing too much noise. This larger signal is then fed to the mixer, which generally has higher noise figure. This will improve overall noise figure, NF at the intermediate frequency, IF output.

1.3 Objective

The objectives of the project that are discovered are to design and to simulate the LNA with comparison the performance LNA with different matching network for GPS application for operating frequency 1.575 GHz.

1.4 Scope of Work

The scope of this project is to design the LNA for GPS application for frequency 1.52GHz. This project should be dividing into four parts which are:

a) Calculation of the stability, gain and noise figure.
b) Simulate the LNA circuit by using Microwave office (AWR).
c) Parameters should summarize and analysis such as the noise figure, power gain, voltage supply and stability performance. The comparison between calculation and simulation was analyzed.
d) The matching networks are included in LNA design such as lumped element, quarter wave and stub.

1.5 Thesis outline

Generally, the report will consist of five chapters which are; Chapter 1: Introduction, Chapter 2: Literature Review, Chapter 3: Methodology, Chapter 4: Results and Analysis and Chapter 5: Conclusion and Future works.

The first chapter is representing the Introduction part. It is contain the project background, problem statement, objectives, scope of project and discovered for the whole project.

The second chapter represented the literature review that involves in this project. The second chapter is about GPS and LNA. In this chapter also will give the information about the GPS and the theory on the LNA and how to design it.

The third chapter which is representing the methodology part will cover on the related methodologies applied in the project. The steps on designed the single stage

LNA starting from the selected transistor, all the calculation involve in order to design, obtain the simulation by using AWR software.

The fourth chapter represents the result and analysis of the project. Here, the analysis of the result obtained will be discussed briefly. The result form calculation, simulation and fabricate would be compared.

The last chapter should be the conclusion and the future work for this project.

CHAPTER II

LITERATURE REVIEW

This chapter discusses about GPS and LNA in general. The S-parameter, DC biasing, matching network and Smith Chart also will be elaborate through this chapter including the definitions used in designing the LNA.

2.1 GLOBAL POSITIONING SYSTEM (GPS)

The Global Positioning System (GPS) is a satellite-based navigation system that was developed by the U.S Department of Defense (DoD) in the early 1970s. Beginning, GPS was developed as a U.S military system to fulfill U.S. military needs. However, it was later to make available to civilians, and is now a dual-use system that can be accessed by both military and civilian users.

GPS provide continuous positioning and timing information, anywhere in the world under weather conditions. Because it serves an unlimited number of users as well as being used for security reasons, GPS is a one-way-ranging (passive) system [1]. That is, user can only receiver the satellite signal.