DESIGN OF A BROADBAND AMPLIFIER BASED ON TWA FOR BROADBAND APPLICATION

NURULISWA BINTI ABDULLAH

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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NURULISWA BINTI ABDULLAH

This report is submitted in partial fulfillment of requirements for the award the degree of Bachelor in Electronic Engineering (Telecommunication) with honours

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MOHAMAD ZOINOL ABIDIN B ABD AZIZ
Pensyarah
Fakulti Kej Elektronik dan Kej Komputer (FKEKK),
Universiti Teknikal Malaysia Melaka (UTeM)
Karung Berkunci 1200,
Ayer Keroh 75450 Melaka

Alamat Tetap: NO 52,
KG PAYA PAHLAWAN,
MUKIM BINJAL,
06000 JITRA,
KEDAH DARUL AMAN.

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To my beloved

My Husband, Muhaimin Zunnur Qoyyum B. Mohd Najib,

My son, ALLAHYARHAM Muhammad Adam B. Muhaimin Zunnur Qoyyum,

And

My family

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ABSTRACT

Using the concept of traveling-wave amplifier gain stage, novel GaAs MMIC distributed amplifiers are designed to achieve high-gain over several octaves of bandwidth. Therefore, this thesis present a Low Noise Amplifier (LNA) design to overcome the weak signal picked up by the antenna. Advance Design System (ADS) is used to design and simulate the LNA circuit from 3 GHz to 10 GHz. The design is obtained by analyzing the forward gain, noise figure, matching network and stability of the circuit. A minimum noise figure of 2dB is obtained from the simulation processed. The maximum gain is 15dB $\pm$ 2 dB. By using the transistor FPD6836P70 PHEMT from Filtronic Semiconductor, UK.

ABSTRAK

Menggunakan konsep mengembara gelombang peringkat gandaan penguat, novel GaAs MMIC penguat diagihkan -penguat direka untuk mencapai peningkatan yang tinggi atas beberapa octaves bagi lebar jalur. Oleh Itu, tesis ini menyampaikan sebuah penguat bunyi yang rendah (LNA) reka bentuk mengatasi lemah menerima pilihan signal meningkat sepasang antena. Bagi merekabentuk dan simulasi bagi litar LNA untuk 3 GHZ hingga 10 GHz menggunakan Sistem Rekabentuk Termaju. Reka bentuk diperolehi dengan menganalisa gandaan ke depan, angka hingar, rangkaian dan kestabilan sepadan litar. Satu minimum angka hingar 2dB adalah didapati daripada simulasi diproses. Peningkatan maksimum adalah 15dB ± 2 dB. Dengan menggunakan transistor FPD6836P70 PHEMT daripada Filtronic Semikonduktor, UK.

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LIST OF ABREVIATIONS

ADS	Advance Design System
B	Bandwidth
CAD	Computer Aided Tool
CMOS	Complementary Metal-oxide Semiconductor
DC	Direct current
DXF	Drawing enhancement file
ETSI	European Telecommunications Standard Institute
F	Noise Figure
FCC	Federal Commission of Communication
FET	Field Effect Transistor
FR4	Flame Retardant 4
Freq	Frequency
GaAs	Gallium Arsenide
GHz	Giga Hertz
HIPERLAN	High Performance Radio Local Area Network
IEEE	Institute of Electrical and Electronic Engineering
ISM	Industrial, Scientific and Medical
K	Rollet stability factor
k	*Boltzman's constant*

LAN	Local Area Network
LNA	Low Noise Amplifier
Mag	Magnitude
MCMC	Malaysian Communication and Multimedia Commission
MESFET	Metal Semiconductor Field Effect Transistor
MHz	Mega Hertz
MMIC	Monolithic Microwave Integrated Circuit
MOSFET	Metal Oxide Field Effect Transistor
N	Noise Figure Parameter
P	Power
pHEMT	Pseudomorphic High Electron Mobility Transistors
R	Resistance
RF	Radio Frequency
RFIC	Radio Frequency Integrated Circuit
UNII	Unlicenced National Information Infrastructure
VSWR	Voltage Standing Wave Ratio
WCC	Wireless Communication Center
WLAN	Wireless Local Area Network

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

In broadband communication, a broadband amplifier is needed to increase the quality of tha signal that is captured by a receiver. Broadband Amplifier based on Traveling Wave Amplifier is largely different to conventional amplifier in term of design and results.

1.2 Objectives

Broadband Low Noise Amplifier (LNA) is an integrated component of most RF systems. With modern communication standards these devices need to be highly linear. The primary aims of this report are to document the learning process involved in the design and testing of a broadband amplifier that been used between 3GHz and 10GHz operating frequencies. The design objectives of a broadband amplifier are to meet the specifications of overall gain at 15 dB ± 2dB, the reflection coefficient, S_{11} and S_{22} below 10dB and the standing wave ratio (SWR) below 2. The amplifier also needs to be input and output matched to 50? impedance. The design uses transistor FPD6836P70 manufactured by Filtronic semiconductor. This project involves the familiarization and utilization of a RF CAD tool and ADS.

1.3 Scope of work

The scope of work involves the circuit level design of Low Noise Amplifier. The computer aided design (CAD) tools are used to design and simulate Low Noise Amplifier. The specifications determined in each component are used for fabrication purpose. Single stage designed method is implemented in designing the circuit with the forward gain, noise figure, matching network and stability analyzed. Then , fourth stage designed method is implemented in designing the complete circuit for TWA with the forward gain, noise figure, matching network and stability analyzed. This project is considered so as to meet the specification of overall gain at 15dB±2dB, the reflection coefficient, S_{11} and S_{22} below -10dB and standing wave ratio (SWR) below 2.

1.4 Problem statement

Although low noise amplifier (LNA) performance is extremely good nowadays, the design engineer still had to make some complex system trades. A good performance of LNA is not always achieved because of the limitation of some factors. In LNA design, the most important factors are low noise, moderate gain, matching and stability. Besides those factors, power consumption and layout design size also need to be considered in the design work. But noise is a critical consideration for lower and higher frequency analog applications. In order to avoid this, the developing of amplifier based on TWA will overcome the problem above. The reason why the devices are connected in TWA is to ensure that the signal power injected at matched input port is coupled and amplified by transconductance Gm of each device before at the end of the matched output will be terminate.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Wideband systems have recently received a great deal of interest due to their potential for high-speed wireless communication. However, there are new challenges to be faced for a feasible transceiver implementation. Ultrawideband (UWB) is a wireless technology that transmits an extremely low power signal over a wide swath of radio spectrum. Ultrawideband systems operate across a wide range of frequencies from 3.1 to 10.6 GHz, as shown in Figure 2.1 below

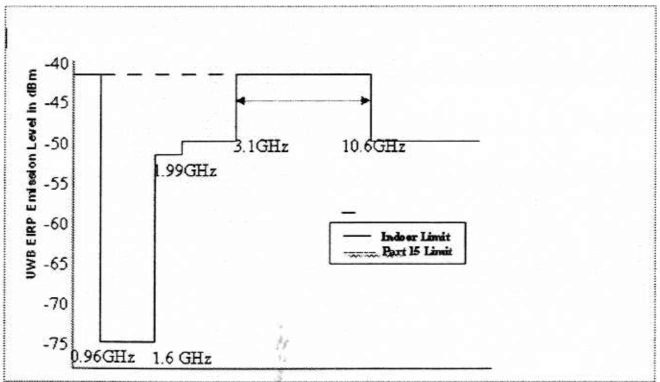

Figure 2.1 Ultrawideband frequency range

Ultrawideband is a pulse-based communication technology. Its transceiver could be greatly simplified, compared with carrier-based technologies. Hence, the cost of ultrawideband could be much lower than traditional wireless communication technologies. As no carrier wave is needed, ultrawideband consumes extremely low power and the long battery life is possible. The frequency spectrum of ultrawideband is very wide and the low frequency components of the spectrum enable the signal penetrate deeply. The data rate of ultrawideband could be as high as 500Mbps, which contain more information that can be transmit and receive. Ultrawideband also have extremely narrow pulse width and low duty cycle cause the ultrawideband signals to be spread over a wide bandwidth resulting in extremely low power spectral densities over GHz bandwidth. Hence, the information is difficult to be intercepted by other devices.

2.1.1 Basic concept in LNA

This chapter develops some basic principles used in the analysis and design of Microwave Low Noise Amplifier (LNA). Based on S parameters of the transistor and certain performance requirements, a systematic procedure is developed for the design of microwave Low Noise Amplifier (LNA). The most important design considerations in a microwave Low Noise Amplifier are stability, power gain, bandwidth, noise, and dc requirements [1]. To ensure the designed circuit fulfils performance requirement and could be install as a practical component in the future, one of the most popular standard followed by the market products, which is developed by Institute of Electrical and Electronic Engineering (IEEE), is taken as the major requirement that designed circuit should achieve. This chapter will discuss about microwave transistor, DC biasing, two port power gain, single-stage design method, stability and noise in two-port.

2.1.1 .1Two port power gain

Two-port network is one of the methods that are widely used in circuit design. There are a few type of two-port network such as Z-network, S-network. All system can be representing as two-port network. Figure 2.2 shows two-port network [S] connected to source and load impedance Z_S and Z_L respectively. The derivation expressions for three types of power gain in terms of *S* parameters of the two-port network are shown below.

- Power Gain: $G = P_L / P_{in}$, is the ratio of power dissipated in the load Z_L to the power delivered to the input of the two-port network. This gain is independent of Z_S.
- Available Gain: $G_A = P_{avn} / P_{avs}$, is the ratio of the power available from the two-port network to the power available from the source. This assumes conjugate matching of both source and the load, and depends on z_S.
- Transducer Power Gain: $G_T = P_L / P_{avs}$, is the ratio of the power available from the two-port network to the power available from the source. This depends both Z_S and Z_L.

These definitions differ primarily in the way the source and load are matched to the two-port device, if the input and output are both conjugated matched to the two-port. Then the gain is maximized and $G = G_A = G_T$.

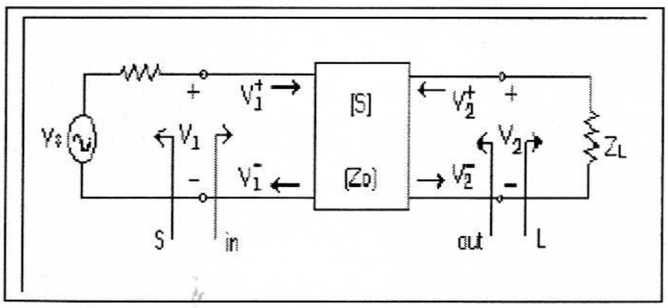

Figure2.2 A two-port network with general source and load impedances.