WIDEBAND SPDT SWITCH FOR RF APPLICATIONS

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Especially for

To beloved parents,

My brother & sister

My supervisor
Mr. Noor Azwan Bin Shairi

And all my friends

For their Love, Encouragements, and best wishes

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ABSTRACT

This project is discussed wideband RF switches for radio frequency (RF) applications. The aim of this project is to increase the bandwidth of the switch as much as possible to be used in various applications. This project is focusing on switch design by using PIN Diode. Besides, this project will use Single Pole Double Throw (SPDT) switch type of the RF switch due to Time Division Duplex which is transmit and receive shared the same frequency. This project is focusing more on the topologies of the SPDT switch in improving bandwidth rather than use different material. This project also discussed each topologies functionality, advantages and disadvantages. The selected topologies are simulated by using Advanced Design Systems (ADS) software. In the simulation result, we will discuss on the insertion loss and isolation of the switch. In order to fabricate the switch in future, our requirement of insertion loss is less than 1 dB and isolation is around 20dB. Modification will be made in topologies in order to maintain its wideband characteristic and improve its insertion loss and isolation. 3 topologies are discussed in this project which is 2 types of series-shunt-shunt topologies and Broadband shunt SPDT switch topology. Tuning of each element in topologies is done by obtaining the best result in simulation section. The best topology is selected as the topology that used in this project and fabrication is carried out on to it by using FR-4 substrate board. Prototypes are measured and comparison between prototypes is done to select the best performance prototype to be final product.

ABSTRAK

Projek ini membincangkan suis RF yang berjalur lebar untuk kegunaan frekuensi radio. Projek ini adalah bagi meningkatkan lebar jalur suis sebanyak yang mungkin untuk diguna pakai dalam pelbagai kegunaan. Projek ini menumpukan atas reka bentuk suis dengan menggunakan PIN Diode. Selain itu, projek ini akan menggunakan suis yang berjenis SPDT disebabkan Time Division Duplex dimana menghantar dan menerima berkongsi frekuensi sama. Dalam projek ini akan berfokus lebih mengenai topologi suis dalam meningkatkan lebar jalur daripada gunakan bahan yang berlainan. Projek ini juga membincangkan setiap kefungsian topologi, kelebihan dan keburukannya. Topologi yang dipilih akan disimulasi dalam ADS (Advanced Design System). Dalam hasil dimulasi, kami akan membincangkan pada kehilangan sisipan dan kuasa pengasingan suis. Keperluan kita untuk mencapai dalan penghilangan sisipan adalah tidak kurang daripada 1dB dan kuasa pengasingan ialah 20dB supaya untuk mereka suis pada masa depan. Pengubahsuaian dalam topology akan dibuat supaya mengekalkan jalur lebarnya dan menurunkan penghilangan sisipan dan meningkatkan kuasa pengasingan. Tiga topologi akan dibincangkan dalam projek ini dimana dua daripadanya ialah jenis series shunt shunt topologi dan satu daripadanya ialah shunt SPDT suis yang berjalur lebar. Penukaran nilai-nilai dalam topologi adalah untuk mendapatkan keputusan yang terbaik dalam seksyen simulasi. Topologi terbaik dipilih sebagai topologi yang menggunakan dalam projek dan pembikinan ini dijalankan dengan menggunakan papan substrat FR4. Prototaip akan diukur dan perbandingan antara prototaip akan dibuat untuk memilih prototaip yang memiliki persembahan yang terbaik untuk menjadikan produk akhir.

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LIST OF ABBREVIATIONS

SPDT	-Single Pole Double Throw
SPST	-Single Pole Single Throw
RF	-Radio Frequency
IL	-Insertion Loss
TDD	-Time Division Duplex
WiMAX	-Worldwide Interoperability for Microwave Access
LTE	-Long Term Evolution
WiBro	-Wireless Broadband
TD_SCDMA	-Time Division Synchronous Code Division Multiple Access
FR4	-Flame Retardant 4

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1. Introduction of Project

This project called “Wideband SPDT Switch for RF Application” which is a switch that can operate in wide frequency range. SPDT stand for Single Pole Double Throw meaning there are total number of 3 ports. 1 port is for antenna and the other 2 ports are for transmitter and receiver. When the antenna is used to transmit signal, the receiver port will isolated from antenna and vice versa. PIN diode HSMP-389Y from Avago Technologies is used in the design for all the topologies. SPDT switch design is focus on the base station application.

1.2. Project Objectives

The objectives of this project are to study different switch topologies and analysis the topologies to be a wideband switch. The best topology will be selected and fabricated by using FR-4 substrate board and measure by using network analyzer.

1.3. Problem Statement

The HSMP-389Y PIN diode is a low performance PIN diode which cannot provide a wideband properties without implement any topologies on it. The single series PIN diode performance as a switch will be discussed and shown below.

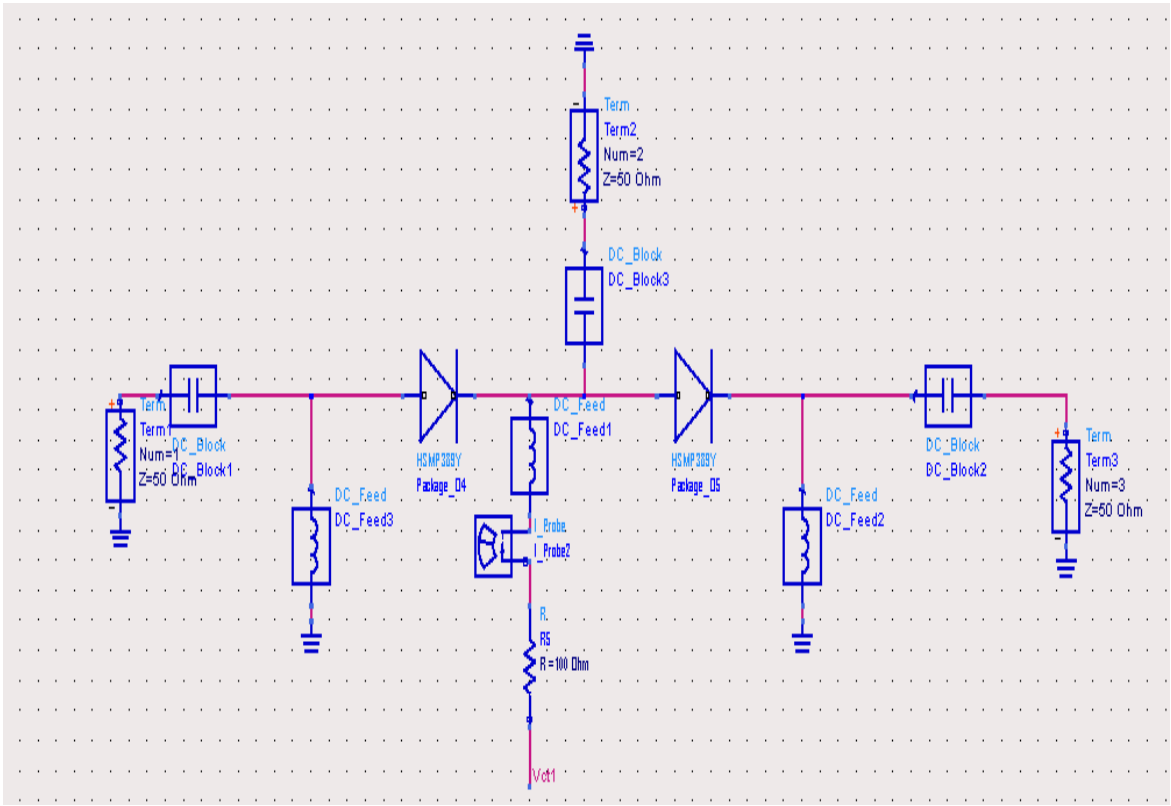

Figure 1.1 Single Series PIN diode switch schematic diagram

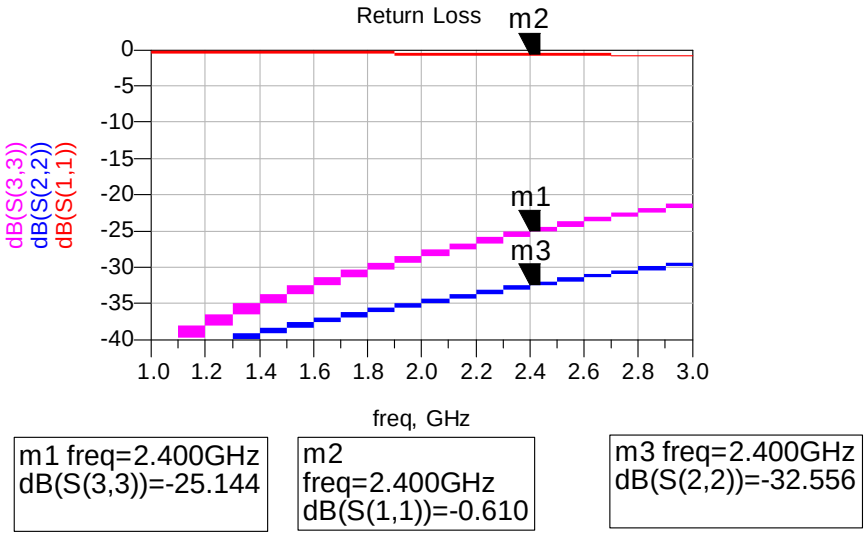

Figure 1.2 Return Loss of Single Series PIN diode switch

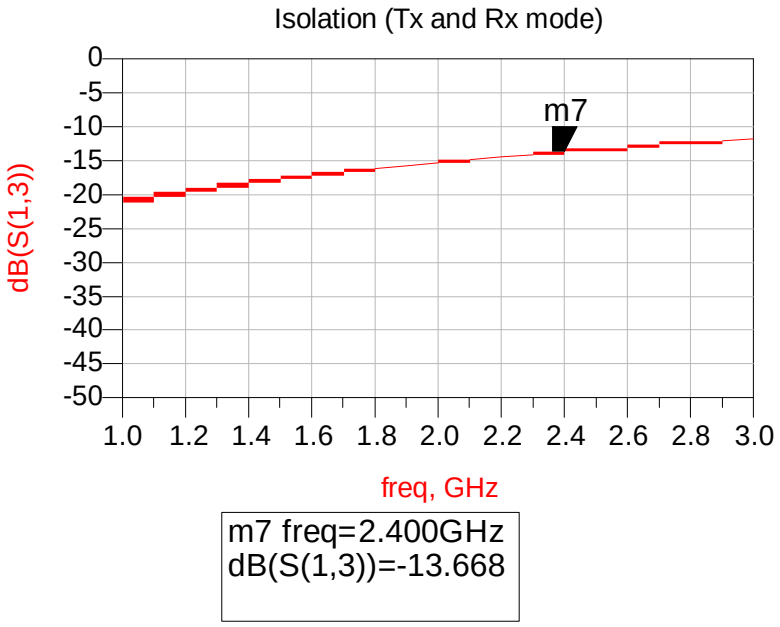

Figure 1.3 Isolation of Single Series PIN diode switch

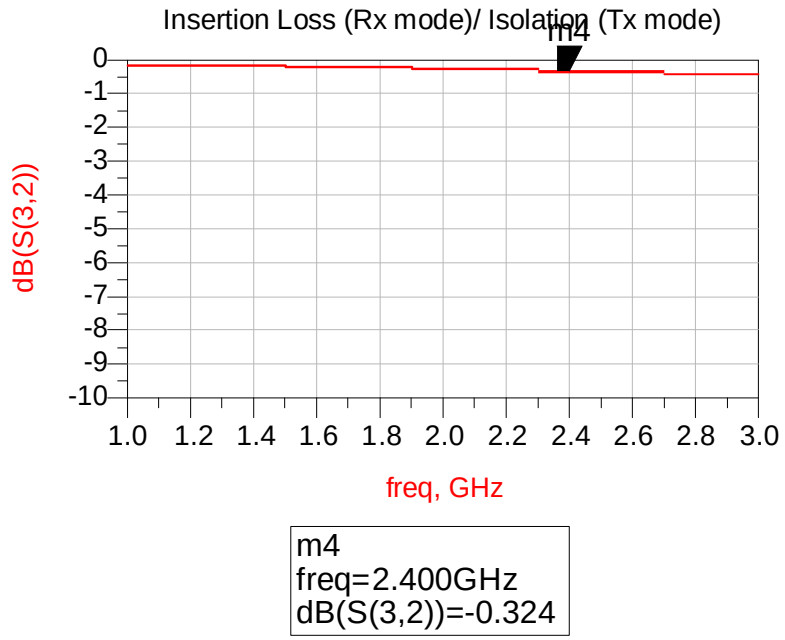

Figure 1.4 Insertion Loss of Single Series PIN diode switch

From the results of single series PIN diode switch, the isolation is only -13dB at frequency 2.4GHz and drop when it going to high frequency. Therefore topology that used in design should provide at least -20dB isolation at any operation frequency range which is only 0.01% signal leakage.

1.4. Project Scopes

The scopes of this project are mainly focus on the switch topologies. Besides that, the characteristic of PIN diode as a switch will also affect the bandwidth of the switch. Based on literature review, those factors will be in count in designing stage. Below are the project scopes:

i. Understanding the basic knowledge of RF switch for WiMAX application.

Understand the differences of DC signal and RF signal in a SPDT switch. The flow of these signals will help in determined the values of component and connection of the circuit.

ii. Understanding the characteristic of PIN diode as a switch

In wideband SPDT switch, there are different component can be act as a switch like Bipolar Junction Transistor (BJT), MESFET, PIN diode and others. The advantages of a PIN diode to be place in this project will be discussed in literature review section.

iii. Determine the suitable topology of SPDT switch for wideband purpose.

Since this project aim is to design a wideband SPDT switch, so the best topology will be refer as a topology which give widest range of frequency and acceptable isolation, insertion loss and return loss.

iv. Analyze and improve the selected switch topologies by using ADS software.

From the selected topologies, improvement will be made on it to obtain the target result in this project. Some topologies might not be the best before modification made but might give the best result after improvement done on it. Thus analysis is needed to ensure best topology is used in this project.

v. RF switch layout in ADS software.

After simulation, the obtained best topology is in schematic diagram and cannot to be used for fabrication. The layout of the switch need to be draw out in ADS software for fabrication purpose.

vi. Fabricate the layout on FR-4 substrate board.

Fabricate the layout draw in ADS software on a FR-4 substrate board. Soldering of each element in schematic diagram is needed in order to complete the prototype.

vii. Test the prototype Scattering Parameter by using network analyzer.

The best topology result in simulation is compared with the measurement result. Analysis will be carrying out on the comparison and discussion and comment will be making on it. S-parameter is use in this project due to its easy implementation on a 3 port network

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1.5. Structure of the Report

In this report will cover the objectives, background, simulation, measurement, results and conclusion of this project. Discussion of the circuit design is included in chapter 4 and recommendation of this project is written in chapter 5.

CHAPTER 2

LITERATURE REVIEW

2.1 RF Switch

RF switch is commonly used in RF transceiver system to perform Time Division Duplex switching for transmit and receive operation. In microwave systems, the transceiver requires several switches which are low-power switches and high power switches. Low power switches are used in phase shifters and attenuators while high power switches is normally used in radar application and communication systems. Besides that, the switches can also be categorized into 2 categories which are reflective and non-reflective. Reflective switches are switches that are closed between ports In and Out 1, port Out 2 is not connected or it is open and any signal appearing at this port will be reflected. Non-reflective switches are not suitable in many applications due to the introduction of significant standing wave between the components. Switches having the unused port terminated in 50 ohm are non-reflective.