

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 dipakai 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 kefungsiian 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 dalam 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.

TABLE OF CONTENT

CHAPTER	TITLE	PAGE
	INTRODUCTION	i
	DECLARATIONN OF PSM II REPORT	ii
	DECLARATION	iii
	SUPERVISOR APPROVAL	iv
	DEDICATION	v
	ACKNOWLEDGEMENT	vi
	ABSTRACT	vii
	ABSTRAK	viii
	TABLE OF CONTENTS	ix
	LIST OF FIGURE	xiii
	LIST OF TABLE	xvi
	LIST OF ABBREVIATIONS	xvii
	LIST OF APPENDICES	xviii
1	INTRODUCTION	1
	1.1 Introduction of Project	1
	1.2 Project Objectives	2

1.3	Problem Statement	2
1.4	Project Scopes	4
1.5	Structure of the Report	6
2	LITERATURE REVIEW	7
2.1	RF Switch	7
2.1.1	Switch Parameter Definitions	8
2.1.1.1	Insertion Loss	8
2.1.1.2	Isolation	9
2.2	WiMAX	9
2.3	PIN Diode HSMP-389Y	10
2.3.1	Characteristic of PIN diode	12
2.4	Broadband Switches	12
3	RESEARCH METHODOLOGY	13
3.1	Methodology Introduction	13
3.1.1	Project Flow Chart	14
3.2	Advanced Design System (ADS)	16
3.3	Schematic Design	16
3.4	Layout Design	19
3.4.1	Converting ideal component to reality component	20
3.4.1.1	Calculation for value capacitors and inductors	20
3.4.1.2	Adding in Transmission Line	21
3.4.1.3	Implement Existing Component	22

3.4.2	Generate Layout	23
3.4.3	Layout Schematic	23
3.5	Fabricated Prototype	24
3.6	Measurement	25
3.6.1	Electronic Calibration	26
4	RESULT AND DISCUSSION	27
4.1	Simulation result of first topology	27
4.2	Simulation result of second topology	35
4.3	Simulation result of third topology	42
4.3.1	Improvement of Topology	47
4.4	Simulation of Layout Design	53
4.5	Measurement of Prototype	59
4.6	Component List of Prototype	69
4.7	Comparison Between Two Prototypes	71
5	CONCLUSION	72
5.1	Conclusion	72
5.2	Recommendation	73
	REFERENCES	74

LIST OF FIGURES

FIGURE	TITLE	PAGE
1.1	Single Series PIN diode switch schematic diagram	2
1.2	Return Loss of Single Series PIN diode switch	3
1.3	Isolation of Single Series PIN diode switch	3
1.4	Insertion Loss of Single Series PIN diode switch	4
2.1	Example of SPDT switch in Transceiver Block Diagram	8
2.2	Hierarchy of PIN diode HSMP-389Y	11
3.1	Methodology Flow Chart	15
3.2	Series-shunt-shunt topology with 2 dc biasing method	17
3.3	Series-shunt-shunt topology with 3 DC biasing method	18
3.4	Broadband shunt SPDT switch topology	18
3.5	Layout Design in Schematic Diagram	19
3.6	Libraries of Murata Components	22
3.7	Layout Generate Command	23
3.8	Top layer view of layout	23
3.9	Bottom layer view of layout	24
3.10	Prototype of Design	24
3.11	Example of Network Analyzer	25
3.12	Example of Network Analyzer Calibrator	26
4.1	Schematic Diagram of First Topology	29
4.2	Return Loss S11, S22 & S33	30
4.3	Isolation Between Transmit and Receive	30
4.4	Insertion Loss	31

4.5	Isolation of Receive Mode	31
4.6	Return Loss S11, S22 & S33	32
4.7	Isolation Between Transmit and Receive	32
4.8	Insertion Loss	33
4.9	Isolation of Transmit Mode	33
4.10	Schematic Diagram of Second Topology	36
4.11	Return Loss S11, S22 & S33	37
4.12	Isolation Between Transmit and Receive	37
4.13	Insertion Loss	38
4.14	Isolation of Receive Mode	38
4.15	Return Loss S11, S22 & S33	39
4.16	Isolation Between Transmit and Receive	39
4.17	Insertion Loss	40
4.18	Isolation of Transmit Mode	40
4.19	Schematic Diagram of Third Topology	42
4.20	Return Loss S11, S22 & S33	43
4.21	Isolation Between Transmit and Receive	43
4.22	Insertion Loss	44
4.23	Isolation of Receive Mode	44
4.24	Return Loss S11, S22 & S33	45
4.25	Isolation Between Transmit and Receive	45
4.26	Insertion Loss	46
4.27	Isolation of Transmit Mode	46
4.28	Schematic Diagram of Improved Topology	47
4.29	Return Loss S11, S22 & S33	48
4.30	Isolation Between Transmit and Receive	48
4.31	Insertion Loss	49
4.32	Isolation of Receive Mode	49
4.33	Return Loss S11, S22 & S33	50
4.34	Isolation Between Transmit and Receive	50
4.35	Insertion Loss	51

4.36	Isolation of Transmit Mode	51
4.37	Layout design of series-shunt-shunt topology with 2 DC biasing method	54
4.38	Return Loss S11, S22 & S33	55
4.39	Isolation Between Transmit and Receive	55
4.40	Insertion Loss	56
4.41	Isolation of Receive Mode	56
4.42	Return Loss S11, S22 & S33	57
4.43	Isolation Between Transmit and Receive	57
4.44	Insertion Loss	58
4.45	Isolation of Transmit Mode	58
4.46	Return Loss S11, S22 & S33	60
4.47	Isolation Between Transmit and Receive	60
4.48	Insertion Loss	61
4.49	Isolation of Receive Mode	61
4.50	Return Loss S11, S22 & S33	62
4.51	Isolation Between Transmit and Receive	62
4.52	Insertion Loss	63
4.53	Isolation of Transmit Mode	63
4.54	Return Loss S11, S22 & S33	64
4.55	Isolation Between Transmit and Receive	64
4.56	Insertion Loss	65
4.57	Isolation of Receive Mode	65
4.58	Return Loss S11, S22 & S33	66
4.59	Isolation Between Transmit and Receive	66
4.60	Insertion Loss	67
4.61	Isolation of Transmit Mode	67
4.62	Components Labeling Schematic	68

LIST OF TABLES

TABLE	TITLE	PAGE
4.1	Simulation Result of First Topology	34
4.2	Simulation Result of Second Topology	41
4.3	Simulation Result of Third Topology	47
4.4	Simulation Result of Improved Topology	52
4.5	Simulation of Layout Design	59
4.6	Comparison of simulation result and measurement result of prototype 1	64
4.7	Comparison of simulation result and measurement result of prototype 2	69
4.8	Component List	70
4.9	Comparison between two prototypes	71

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

INDEX	TITLE	PAGE
A	Tyco Inductors Data Sheet	75
B	Layout Design Schematic	76

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.

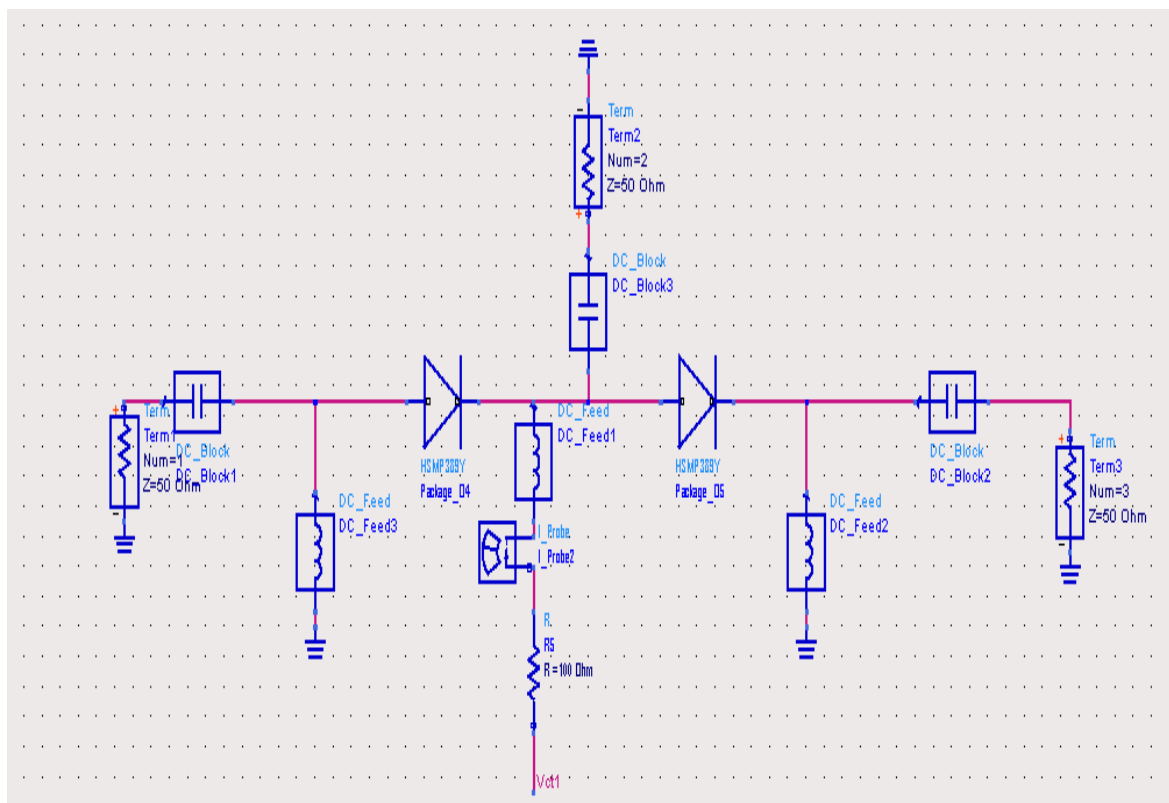


Figure 1.1 Single Series PIN diode switch schematic diagram

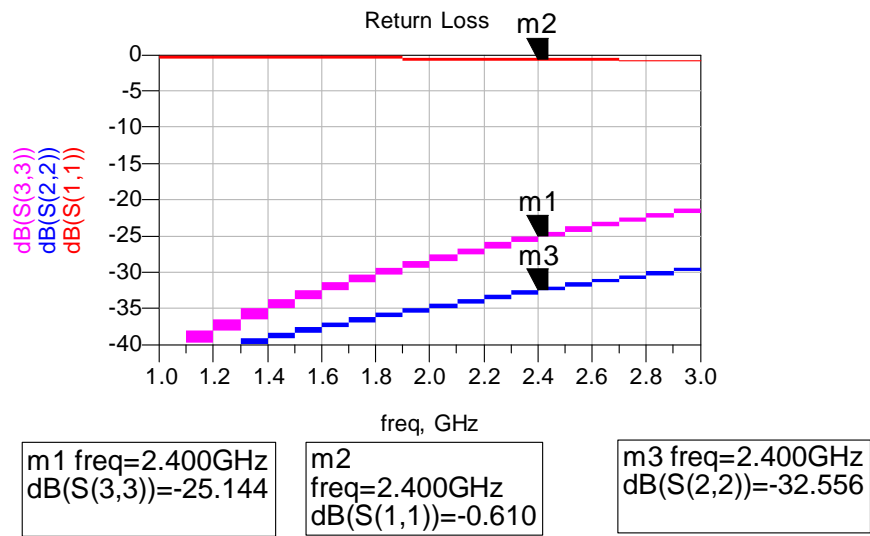


Figure 1.2 Return Loss of Single Series PIN diode switch

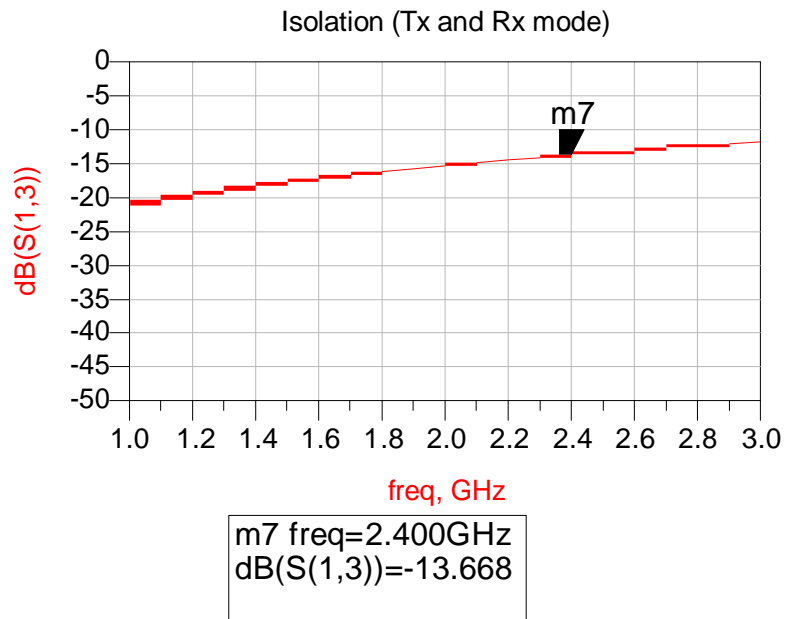


Figure 1.3 Isolation of Single Series PIN diode switch

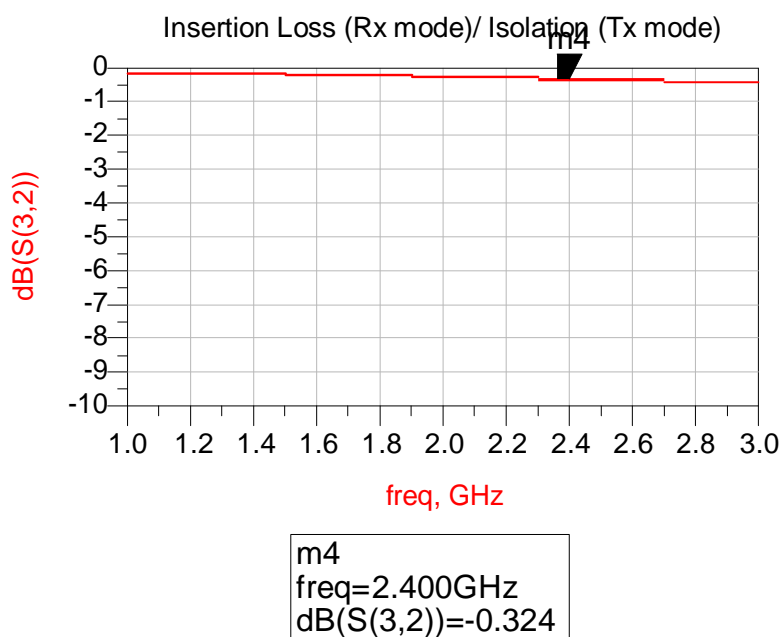


Figure 1.4 Insertion Loss of Single Series PIN diode switch

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

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.