

**DESIGN AND ANALYSIS OF A DUAL FUNCTION OF  
SWITCHABLE RESONATOR FOR RF SWITCH**

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**DESIGN AND ANALYSIS OF A DUAL FUNCTION OF  
SWITCHABLE RESONATOR FOR RF SWITCH**

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**This report is submitted in partial fulfilment of the requirements  
for the degree of Bachelor of Electronic Engineering with Honours**

**Faculty of Electronic and Computer Engineering  
Universiti Teknikal Malaysia Melaka**

**2019**

BORANG PENGESAHAN STATUS LAPORAN  
PROJEK SARJANA MUDA II

Tajuk Projek : DESIGN AND ANALYSIS OF A DUAL  
FUNCTION OF SWITCHABLE RESONATOR  
FOR RF SWIRCH  
Sesi Pengajian : 2018/2019

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# **DEDICATION**

To my family and friends

## ABSTRACT

In wireless data communications using Time Duplex Division (TDD), Single Pole Double Throw Switch (SPDT) Switch is used to switch between transmit mode (Tx) and receive mode (Rx) in RF front-end system. The SPDT switch is used in Modern Wireless Communication Systems. So far, existing application switch does not have a dual function between isolation improvement and bandstop feature in Single Pole Double Throw Switch (SPDT) Switch because the main parameter of RF Switch is focusing on isolation performance. In order to achieve the dual function between isolation improvement and bandstop feature in SPDT switch, we use a switchable resonator. The switching element that we use is PIN diode. The advantage of this technique is to reduce of size of the circuit with minimum usage of switching elements compared to the technique using multiple PIN diodes. The design involves simulation using Advance Design System (ADS) software 2011 and fabricated using FR4 board. The S-parameters of the switch are analyzed in the ADS software. The circuit of the switch is designed as layout in ADS software and prepare for fabrication process. Measurement is necessary for verification with simulation results. Both simulated result and measurement result were successfully achieved high isolation performance of more than 30dB with minimum number of PIN didoes

## ABSTRAK

*Dalam komunikasi data tanpa wayar yang menggunakan Time Division Duplex (TDD), Switch Single Pole Double Throw (SPDT) digunakan untuk bertukar antara mod penghantaran (Tx) dan mod menerima (Rx) dalam sistem hadapan RF. Suis SPDT digunakan dalam Sistem Komunikasi Wayarles Modem. Setakat ini, suis aplikasi yang sedia ada tidak mempunyai fungsi dwi antara penambahbaikan pengasingan dan ciri bandstop dalam Switch Single Pole Double Throw (SPDT) kerana parameter utama RF Switch adalah memfokuskan kepada prestasi pengasingan. Untuk mencapai fungsi dwi antara penambahbaikan pengasingan dan ciri bandstop dalam suis SPDT, kami menggunakan resonator switchable. Unsur penukaran yang kita gunakan adalah diod PIN. Kelebihan teknik ini adalah untuk mengurangkan saiz litar dengan penggunaan minimum elemen pensuisan berbanding dengan teknik menggunakan multiple diodes PIN. Reka bentuk ini melibatkan simulasi dengan menggunakan perisian Advance Design System (ADS) 2011 dan direka menggunakan papan FR4. S-parameter suis dianalisis dalam perisian ADS. Litar suis ini direka bentuk sebagai susun atur dalam perisian ADS dan menyediakan proses fabrikasi. Pengukuran diperlukan untuk pengesahan dengan keputusan simulasi. Kedua-dua keputusan simulasi dan pengukuran berjaya mencapai prestasi pengasingan tinggi lebih daripada 30dB dengan bilangan minimum PIN diodes.*



## ACKNOWLEDGEMENTS

Firstly, I would like to express my deepest appreciation to everyone who help me throughout the time of my final year project with their advice, idea, guidance and mental support.

Next, I would like to express my feeling to my supervisor Dr. Noor Azwan bin Shairi who always help and guide me with his patience and motivate way. With his guidance, I can easily understand and learn the knowledge about RF switch. I am truly grateful that my supervisor can give me some helping hand on my project as well as with the thesis.

Besides, I also would like to say thank you to my parents who always support me along the way of completing this final year project. Also, I would like to thank my course mates, PhD seniors and lab assistant for giving some helping hand in difficult time.

# TABLE OF CONTENTS

<b>Declaration</b>	
<b>Approval</b>	
<b>Dedication</b>	
<b>Abstract</b>	<b>ii</b>
<b>Abstrak</b>	<b>iii</b>
<b>Acknowledgements</b>	<b>iv</b>
<b>Table of Contents</b>	<b>v</b>
<b>List of Figures</b>	<b>viii</b>
<b>List of Tables</b>	<b>xi</b>
<b>List of Symbols and Abbreviations</b>	<b>xii</b>
<b>List of Appendices</b>	<b>xiii</b>
<b>CHAPTER 1 INTRODUCTION</b>	<b>1</b>
1.1 Research Background	1
1.2 Problem Statement	3
1.3 Objectives	4
1.4 Scope of Work	4

1.5	Project Significance	5
1.6	Organization of Thesis	5
<b>CHAPTER 2 BACKGROUND STUDY</b>		<b>6</b>
2.1	RF Switch	6
2.1.1	Configurations of RF Switch	9
2.1.2	Operations of RF Switch	10
2.1.3	Characteristics of RF Switch	11
2.1.3.1	Isolation	11
2.1.3.2	Insertion Loss	12
2.1.3.3	Return Loss	12
2.1.4	Time Division Duplex	12
2.1.5	Frequency Division Duplex	13
2.2	PIN Diode	14
2.3	Transmission Line	15
2.3.1	Microstrip Transmission Line	16
2.4	Research Work from Previous Researchers	17
<b>CHAPTER 3 METHODOLOGY</b>		<b>26</b>
3.1	Project Flow Chart	27
3.2	Software Requirement	29
3.3	Hardware Requirement	29

3.4	Mathematical Modelling	30
3.4.1	Switchable Transmission Line Open Stub Resonators	30
3.5	Simulation and Layout	33
3.6	Fabrication, Soldering and Measurement	37
3.7	Dual function of switchable resonator for SPDT switch	38
3.8	Summary	40
<b>CHAPTER 4 RESULTS AND DISCUSSION</b>		<b>41</b>
4.1	Result of A Dual Function of Switchable Resonator for RF Switch	41
4.1.1	Prototype of a Dual Function of Switchable Resonator for RF Switch Switchable	41
4.1.2	Simulation Results	42
4.2	Comparison Result of Simulation and Measurement	45
4.3	Summary	47
<b>CHAPTER 5 CONCLUSION AND FUTURE WORKS</b>		<b>48</b>
5.1	Conclusion	48
5.2	Recommendations for Future Works	49
<b>REFERENCES</b>		<b>50</b>
<b>LIST OF PUBLICATIONS AND PAPERS PRESENTED</b>		Error! Bookmark not defined.
<b>APPENDICES</b>		<b>54</b>

## LIST OF FIGURES

Figure 1.1: An example application of SPDT switch in wireless data communications	2
Figure 2.1: SPDT switch in RF-front end	8
Figure 2.2: DPDT switch in RF-front end	9
Figure 2.3: Series RF switch	9
Figure 2.4: Shunt RF switch	10
Figure 2.5: Series-Shunt RF switch	10
Figure 2.6: Time Division Duplex (TDD)	13
Figure 2.7: Frequency Division Duplex (FDD)	13
Figure 2.8: Cross Section of Basic Diode	15
Figure 2.9: PIN Diode Equivalent Circuits (a) Forward bias (b) Reverse bias	15
Figure 2.10: Typical Transmission Structure	16
Figure 2.11: Microstrip Transmission Line	17
Figure 2.12: Switchable microstrip line open stub resonator for single microstrip line	18
Figure 2.13: Switchable microstrip line open stub resonator for two microstrip line	19
Figure 2.14: Operation of single switchable open stub resonator	19
Figure 2.15: General diagram of open stub resonator	20
Figure 2.16: Circuit Operation of Switchable Transmission Line Stub Resonator	20

Figure 2.17: ON State (Bandstop Response)	21
Figure 2.18: OFF State (Allpass Response)	21
Figure 2.19: Comparison of Isolation Performance of SPDT switches from other Researchers	21
Figure 2.20: Proposed switchable radial stub resonator using PIN diode	23
Figure 2.21: Bandstop response when PIN diode is in ON state	23
Figure 2.22: Allpass response when PIN diode is in OFF state	23
Figure 3.1: Overall Project Flow Chart	27
Figure 3.2: Simplified outline of BAP64-02	30
Figure 3.3: General Diagram of Transmission Line Open Stub Resonator	30
Figure 3.4: Schematic windows in ADS software	33
Figure 3.5: S-parameter	34
Figure 3.6: Material specifications for FR4 board	34
Figure 3.7: Layout windows in ADS software	35
Figure 3.8: Convert schematic to layout	36
Figure 3.9: Printed layout design for a dual function switchable resonator	36
Figure 3.10: Agilent Network Analyzer	37
Figure 3.11: Circuit diagram for switchable resonator for SPDT switch	38
Figure 3.12: Circuit diagram for switchable resonator for SPDT switch during Transmit mode	39
Figure 3.13: Circuit diagram for switchable resonator for SPDT switch during Receive mode	39
Figure 4.1: Prototype of a dual function of switchable resonator for RF switch	42
Figure 4.2: Simulation results during Transmit mode	43
Figure 4.3: Simulation results during receive mode	43

Figure 4.4: Comparison of simulated and measurement for Return Loss	45
Figure 4.5: Comparison of simulated and measurement for Insertion Loss	46
Figure 4.6: Comparison of simulated and measurement for isolation performance	46

## LIST OF TABLES

Table 2.1: Configurations of RF Switch	7
Table 2.2: Summarizations of RF switch designs in wideband, broadband and multiband applications	24
Table 3.1: Software used in the project	29
Table 3.2: Components used in the project	29
Table 3.3: Operation process between transmit mode and receive mode	40
Table 4.1: Simulation results during transmit mode and receive mode	44



## LIST OF SYMBOLS AND ABBREVIATIONS

ADS	:	Advance Design System
DC	:	Direct Current
DPDT	:	Double Pole Double Throw
DPST	:	Double Pole Single Throw
FDD	:	Frequency Division Duplex
FET	:	Field Electric Transistor
LNA	:	Low Noise Amplifier
LTE	:	Long-Term Evolution
MEM	:	Micro-Electro-Mechanical
RF	:	Radio Frequency
PIN	:	Positive-Intrinsic-Negative
SPDT	:	Single Pole Double Throw
SPST	:	Single Pole Single Throw
TDD	:	Time Division Duplex
TD-SCDMA	:	Time Division Synchronous Code Division Multiple-Access
WIFI	:	Wireless Fidelity
WiMAX	:	Worldwide Interoperability for Microwave Access

## LIST OF APPENDICES

APPENDIX A: DATASHEET OF PIN DIODE (BAP64-02)	52-55
APPENDIX B: SCHEMATIC DESIGN	56

# CHAPTER 1

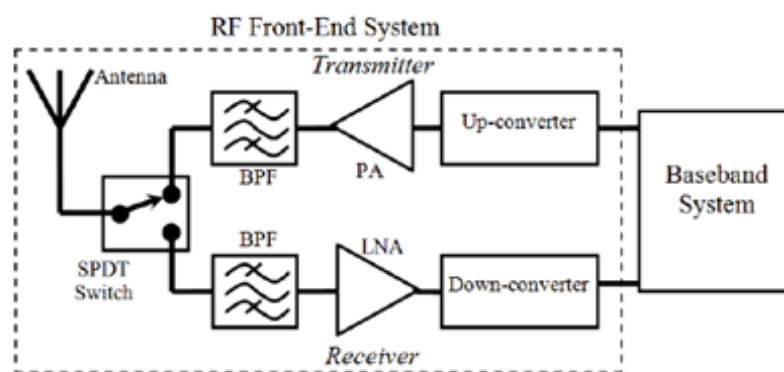
## INTRODUCTION

This chapter explained about the introduction of this project following by the research background, problem statement, objectives and scope of work. Project objectives, scopes of work and expected results from this project also discussed in this chapter. All the details for each section of the project have been discussed in this chapter.

### **1.1 Research Background**

In general, radio frequency (RF) switches are used for signal routing between transmitter and receiver. There are 2 main switching elements of RF switches which are micro-electro-mechanicals (MEMs) and solid-state RF switches for example PIN diode and field effect transistor (FET). [1] The PIN diode is a semiconductor device produced for RF and microwave frequencies which is used to control the shape and

the conductivity of a channel by a unique specification of varying resistance by changing the current. MEMs switches have limited power capabilities. Hence, it is not suitable for high power applications. Meanwhile, solid state RF switches for example PIN diode demonstrate a higher reliability because solid state switches have faster switching time between transmitter and receiver and can achieve a longer life span compared to MEMs. PIN Diode is the most popular switching element used in solid state RF switches.



**Figure 1.1: SPDT switch in wireless data communications**

Moreover, RF switch is commonly used to route signals and transmit RF signals from antennas to the transmitter (Tx) and receiver (Rx) in wireless data communications. Nowadays, RF switches such as Single Pole Double Throw Switch (SPDT) Switch and Double Pole Double Throw (DPDT) switch are mostly used in civilian wireless communication system. Examples of civilian wireless communication systems for data exchange in different standards are Time Division Synchronous Code Division Multiple-Access (TD-SCDMA), Wireless Fidelity (WiFi), Worldwide Interoperability for Microwave Access (WiMAX), and other applications. [2]

The most significant parameter in RF switch design is the isolation performance between transmitter (Tx) and receiver (Rx). Isolation is the key feature to achieve a

good performance of the circuit design. High isolation can minimize any leakage of high RF power transmit from transmitter to receiver that might alter the active circuits of receiver for example low noise amplifier (LNA). There are several ways to improve the isolation performance such as the configurations of multiple connection of PIN diodes which are either connect in series, shunt or series-shunt. Besides, isolation performance can also be improved by using material with fabrication process. Another technique to improve the isolation performance is through resonated switch element with inductor or capacitor.

## **1.2 Problem Statement**

So far in wireless data communications, existing application switch does not have a dual function between isolation improvement and bandstop feature in Single Pole Double Throw Switch (SPDT) Switch because the main parameter of RF Switch is focusing on isolation performance. There are several ways to improve the isolation performance such as the configurations of multiple connection of PIN diodes are either connect in series, shunt or series-shunt. However, using multiple PIN diodes, the size of the circuit will increase. Therefore, this project proposed a dual function of switchable resonator as isolation improvement and bandstop feature in Single Pole Double Throw Switch (SPDT) Switch because it offered circuit simplicity, low cost and circuit size reduction.

### **1.3 Objectives**

The objectives of this project are:

1. To design a dual function of switchable resonator as isolation improvement and bandstop feature in Single Pole Double Throw Switch (SPDT) Switch.
2. To fabricate and analyze the designed switch in order to validate the simulation results.

### **1.4 Scope of Work**

The scope of work of this project is to design a dual function of switchable resonator as isolation improvement and bandstop feature in Single Pole Double Throw Switch (SPDT) Switch using Advance Design System (ADS) software 2011. For the switching element, a discrete PIN diode was chosen. The PIN diode model was from NXP Semiconductors (part number: BAP64-02). Single Pole Double Throw Switch (SPDT) design was chosen for the PIN diode design configuration. Simulation process will be performed using Advance Design System (ADS) software 2011. The S-parameters of the design switch was analysed in the ADS software. Next, the designed circuits of the RF switch was fabricated using FR4 board to validate the performance of the switchable resonator. Measurement is necessary for the verification of the results.

## **1.5 Project Significance**

In this project, Single Pole Double Throw Switch (SPDT) switch that have dual function between isolation improvement and bandstop feature in the Single Pole Double Throw Switch (SPDT) will be designed. Therefore, the significance for this project is to reduce the size of the circuit. When the size of the circuit is reduced, the current consumption of the circuit will decrease as this will have less power consumption. Less power consumption will bring the positive impact to the environment.

## **1.6 Organization of Thesis**

This thesis consists of five chapters. Chapter 1 illustrates the general overview of the project, background research about RF switch, problem statement, objectives and scope of work. Chapter 2 describes the literature review of the RF and microwave switches, characteristics of RF switches and PIN diode. The techniques used for isolation improvement in RF switch from previous research are also explained in detail in this chapter. Chapter 3 elaborates the methodology of this project. In this chapter, the detail procedure of this project will be explained. The procedure of the project includes simulation, fabrication and measurement. Chapter 4 discussed the results obtained from simulation and measurement. The results are analysed and justify the achievement of the objective of the project. Chapter 5 highlights the conclusion of this thesis and the suggestion for future work that related to this study.

## **CHAPTER 2**

### **BACKGROUND STUDY**

This chapter discusses the background studies related to this project, related previous research and explains in detail about the review for the previous research papers and journals. Ideas and techniques were obtained from those journals and research papers.

#### **2.1 RF Switch**

RF switches are used for signal routing between transmitter and receiver. There are 2 main switching elements of RF switches which are micro-electro-mechanicals (MEMs) and solid-state RF switches such as PIN diode and field effect transistor (FET). MEMS switches are dominating over solid-state technology because of their compact size, low power consumption, low insertion loss and high isolation