شبكة المعلومات الجامعية

التوثيق الإلكتروني والميكروفيلم

بسم الله الرحمن الرحيم

HANAA ALY

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جامعة عين شمس

التوثيق الإلكتروني والميكروفيلم

قسم

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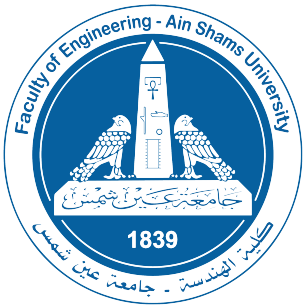


AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
Electronics and Electrical Communications Department

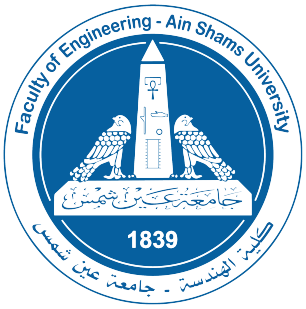
Applications of Multi-mode Junctions in Passive Microwave Components

A Thesis submitted in
partial fulfillment of the
Master of Science in Electrical Engineering
(Electronics and ELectrical Communication Department)

by
Mohamed Hussein Aly Elsawaf
Bachelor of science in electrical engineering, electronics and electrical communications department
Faculty of Engineering, Ain Shams, 2018

Supervised By
Prof. Khaled Mohamed Wagih Sharaf
Prof. Amr Mohamed Ezzat Safwat

Cairo, 2021



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STATEMENT

This Thesis is submitted as a partial fulfillment of master of science in electrical engineering (Electronics and electrical communications), Faculty of Engineering, Ain Shams University. The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

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DEDICATION

This thesis is dedicated to the soul of my Mother. May mercy fall upon her soul.

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First of all, thanks to allah for reconciling me into this thesis. The gratitude is also paid to my dear father for his continuous support during this period. Tributes are paid to my beloved mother, whom I had wished to be there with me.

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Finally I thank Allah for this work, and pray for him to prevail his favors among us.

ABSTRACT

In this thesis, symmetric three-conductor multi-mode junctions are exploited to design novel passive microwave components. The main goal is to build a fully-differential beamforming network for 5G applications. For that purpose, the junctions are applied in the design of couplers with different port configurations i.e. single-ended, single-ended to differential, and fully-differential configurations.

The thesis is divided into seven chapters as listed below:

Chapter 1:

This chapter gives a brief presentation of the motivation, objectives, and major contributions. It also discusses the organization of the thesis.

Chapter 2:

This chapter presents a literature survey of the state-of-the art beamforming networks. It introduces static beamforming networks like Butler and Nolen matrices. Later, it focuses on the Butler matrix and its constituent components i.e. couplers, crossovers, and phase shifters.

Chapter 3:

This chapter starts by giving a quick overview of the multi-mode cross-junction and its applications. Next, it proposes the novel multi-mode star-junction with 8 three-conductor structures, 16 electrical ports, connected in a star configuration. The proposed junction is applied to the design of miniaturized hybrid and rat-race couplers with single-ended ports.

Chapter 4:

This chapter extends the applications of the star-junctions to design fully-differential hybrid and rat-race couplers. The chapter starts with the design methodology of differential hybrid and rat-race couplers using slotline technology. Later, it provides their realization using the star-junction. It also introduces a slot-line to differential microstrip coupled line transition. The proposed couplers have wider bandwidth than that the state-of-the-art couplers. The usage of slotline makes the couplers superior in terms of common-mode rejection ratio, common-mode and mode conversion rejection fractional bandwidths.

Chapter 5:

This chapter gives the design guidelines of single-ended to differential rat-race coupler with combined microstrip/slotline ports. The couplers use the design methodology presented in Chapter 3. They also use the transitions introduced in Chapter 4. The proposed coupler

exploit the characteristics of the slotline ports to achieve a high common-mode rejection ratio, wide common-mode and mode conversion rejection fractional bandwidths.

Chapter 6:

This chapter introduces an alternative design methodology to realize single-ended to differential hybrid coupler with microstrip/slotline ports. This alternative methodology achieves wider differential bandwidth at the expense of a relatively larger size than the state-of-the-art ones. The proposed coupler is then used to design 4×4 fully-differential Butler matrix (BM). The matrix has 50-dB common-mode rejection at the operating frequency. The CM rejection and mode conversion FBWs exceed 375%

Chapter 7:

This chapter gives the conclusion of this thesis and introduces several recommendations and suggestions for future work.

Keywords: Beamforming, Butler matrix, Differential passive Components, Hybrid Couplers, Multi-mode Junctions, Rat-race Couplers, Single-ended to differential couplers.

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