
AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

Electronics Engineering and Electrical Communications

# Metamaterial-Inspired Multimode Structures

A Thesis submitted in partial fulfillment of the requirements of the degree of

Master of Science in Electrical Engineering

(Electronics Engineering and Electrical Communications )

by

**Abdelhamid Mohamed Hatem Abdelhamid Nasr**

Bachelor of Science in Electrical Engineering

(Electronics Engineering and Electrical Communications )

Faculty of Engineering, Ain Shams University, 2014

Supervised By

**Prof. Hadia Mohamed Said El Hennawy**

**Prof. Amr Mohamed Ezzat Safwat**

Cairo - (2018)


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# Statement

This thesis is submitted as a partial fulfillment of Master of Science in Electrical Engineering, 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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**Faculty of Engineering Ain Shams University**

**Electronics and Communication Engineering Department**

Thesis title: "**Metamaterial-Inspired Multimode Structures**"

Submitted by: **Abdelhamid Mohamed Hatem Abdelhamid Nasr**

Degree: **Master of Science in Electrical Engineering**

## Thesis Summary

This thesis aims to use the three conductor waveguide structures, such as coplanar waveguides (CPW), slotted microstrip and coupled lines, that support even and odd modes in designing novel metamaterial-inspired structures. For this purpose, a transformer-based circuit model of three conductor transmission line cross-junction was developed, where each port carried even and odd modes. This model enabled the design of CPW-to-slotline transition, novel air-bridge free CPW Wilkinson power divider, simple microstrip-to-slotline transitions, microstrip Wilkinson power divider with minimum lateral dimensions, and high-coupling slotted microstrip directional coupler.

The thesis is divided into five chapters as listed below:

Chapter 1:

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

Chapter 2:

This chapter presents the literature survey and theory and implementation of Composite Right/Left Handed (CRLH) transmission lines with special emphasis on the even and odd mode based ones. It also presents some metamaterial-inspired microwave applications.

Chapter 3:

This chapter introduces a novel circuit model of multimode cross-junction where each port carries the even and odd modes and its coplanar waveguide applications. The model enables the design of CPW-to-slotline transition and novel air-bridge free CPW-to-slotline Wilkinson power divider.

Chapter 4:

In this chapter, the circuit model of the cross-junction is applied to slotted microstrip cross-junction. The model facilitated the realization of microstrip-to-slotline transitions, slotted microstrip Wilkinson power divider with minimum lateral dimensions and high-coupling phase-compensated directional coupler.

Chapter 5:

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

**Key words:**

Air-bridges, Baluns, Coplanar waveguide (CPW), Cross-junction, Directional couplers, Equivalent circuit model, Microstrip, Parasitic slotline mode, Slotline, Slotted microstrip, Wilkinson power divider.

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