



University
of Victoria

Graduate Studies

PROGRAMME

The Final Oral Examination
for the Degree of

DOCTOR OF PHILOSOPHY
(Department of Electrical and Computer Engineering)

Zamzam Kordiboroujeni

2008	Iran University of Science and Technology	MASc
2005	Iran University of Science and Technology	BASc

“Mode Matching Analysis and Design of Substrate
Integrated Waveguide Components”

Friday, October 24, 2014
10:00 a.m.

Engineering Computer Science Building, room 468

Supervisory Committee:

Dr. Jens Bornemann, Department of Electrical and Computer
Engineering, UVic (Supervisor)

Dr. Poman So, Department of Electrical and Computer
Engineering, UVic (Member)

Dr. Henning Struchtrup, Department of Mechanical Engineering,
UVic (Outside Member)

External Examiner:

Dr. Zhizang (David) Chen, Department of Electrical and Computer
Engineering, Dalhousie University

Chair of Oral Examination:

Dr. Stan Dosso, School of Earth and Ocean Sciences, UVic

Abstract

The advent of Substrate Integrated Circuit (SIC) technology, and specifically Substrate Integrated Waveguide (SIW) technology has made it feasible to design and fabricate low loss and high quality factor (Q-factor) microwave and millimeter wave structures on a compact and integrable layout and at a low cost. The SIW structure is the planar realization of the conventional rectangular waveguide (RWG). In this technology, the side walls of the waveguide are replaced with two rows of metallic vias, which are connecting two conductor sheets, located at the top and bottom of a dielectric slab. The motivation for this thesis has been to develop an analytical method to efficiently analyze SIW structures, and also design different types of passive microwave components based on this technology.

As SIW structures are imitating waveguide structures in a planar format, the field distributions inside these structures are very close to those in waveguides. However, due to the very small substrate height in conventional planar technologies, and also the existence of a row of vias, instead of a solid metallic wall, there is a reduced set of modes in SIW compared to regular waveguide. This fact has given us an opportunity to deploy efficient modal analysis techniques to analyze these structures. In this thesis, we present a Mode Matching Techniques (MMT) approach for the analysis of H-plane SIW structures.

One of the areas of application, which can significantly benefit from having an efficient analytical method, is designing and optimizing new circuits. Having such an analytical tool, which is faster than commercially available field solvers by an order of magnitude, new components can be designed, analyzed and optimized in a fast and inexpensive manner. Based on this technique, various types of passive microwave components including filters, diplexers, power dividers and couplers, some of which are among the first to be reported in SIW technology, are designed and analyzed in this thesis. Also based on this technique, the most accurate formula for the effective waveguide width of the SIW is presented in this thesis.

In order to provide means to excite and measure SIW components, transitions between these structures and other planar topologies like microstrip and coplanar waveguide (CPW) are needed. More importantly, low-reflection transitions to microstrip are required to integrate SIW circuits with active components, and therefore it is vital to provide low-reflection transitions so that the component design is independent of the influences of the transitions. In this thesis, a new wideband microstrip-to-SIW transition, with the lowest reported reflection coefficient, is also introduced.

Awards, Scholarships, Fellowships

2009 – PhD Award, *University of Victoria*

2012 – Travel Grant, *University of Victoria*

Presentations

1. Kordiboroujeni, Z. “*Modal Analysis and Design of Substrate Integrated Waveguide Components.*” *ECE Graduate Seminar Series*, University of Victoria, Victoria, B.C., Canada. April 2012.
2. Kordiboroujeni, Z. “*Efficient mode-matching design of substrate-integrated waveguide filters.*” *42nd European Microwave Conference (EuMC)*, Amsterdam, The Netherlands, Oct./ Nov. 2012.
3. Kordiboroujeni, Z. “*Mode matching design of substrate integrated waveguide diplexers.*” *IEEE MTT-S International Microwave Symposium (IMS)*, Seattle, WA, USA, June 2013.

Publications

1. Bornemann, J.; Taringou, F. and Kordiboroujeni, Z. “A mode-matching approach for the analysis and design of substrate-integrated waveguide components.” *Frequenz - Journal of RF/Microwave Engr., Photonics and Communications*, **September 2011**, (65) 287-292.
2. Kordiboroujeni, Z.; Bornemann, J. and Sieverding, T. “Mode-matching design of substrate-integrated waveguide couplers.” *Proceedings of Asia-Pacific Symposium on Electromagnetic Compatibility (APEMC)*. **May 2012**. Singapore, 701-704.
3. Kordiboroujeni, Z.; Taringou, F. and Bornemann, J. “Efficient mode-matching design of substrate-integrated waveguide filters.” *Proceedings of 42nd European Microwave Conference*

(EuMC). Amsterdam, The Netherlands, **Oct./ Nov. 2012**, 253-256.

4. Kordiboroujeni, Z. and Bornemann, J. "Efficient design of substrate integrated waveguide power dividers for antenna feed systems." *Proceedings of 7th European Conference on Antennas and Propagation (EuCAP)*, **April 2013**, Gothenburg, Sweden, 352-356.
5. Locke, L.; Kordiboroujeni, Z.; Bornemann, J. and Claude, S. "Substrate integrated waveguide couplers for tapered slot antennas in adaptive receiver applications." *Proceedings of 7th European Conference on Antennas and Propagation (EuCAP)*, **April 2013**, Gothenburg, Sweden, 2865-2869.
6. Kordiboroujeni, Z. and Bornemann, J. "Mode matching design of substrate integrated waveguide diplexers." *IEEE MTT-S International Microwave Symposium (IMS) Digest*, **June 2013**, Seattle, WA, USA, 1-3.
7. Kordiboroujeni, Z. and Bornemann, J. "Designing the width of substrate integrated waveguide structures." *IEEE Microwave and Wireless Components Letters*, **October 2013**, 23 (10):518-520.
8. Kordiboroujeni, Z.; Bornemann, J. and Sieverding, T. "K-Band substrate integrated waveguide T-junction diplexer design by mode-matching techniques." *Asia-Pacific Microwave Conference (APMC)*, **Nov. 2014**, Sendai, Japan.
9. Kordiboroujeni Z. and Bornemann, J. "Mode-matching analysis and design of substrate integrated waveguide T-junction diplexer and corner filter." *International Journal of Numerical Modelling: Electronic Networks, Devices and Fields*, **2014** (In press).