2012 IEEE Antennas and Propagation Society International Symposium (APSURSI)

2012 IEEE AP-S / USNC-URSI
JULY 8-14, 2012
CHICAGO, ILLINOIS, USA

IEEE Catalog Number: CFP12APS-CDR
ISBN: 978-1-4673-0460-3
ISSN: 1522-3965

July 8-14, 2012
Chicago, Illinois USA

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G. Oliveri, M. Carlin, A. Massa, *ELEDIA Research Center - University of Trento, Italy*

11:00 305.8 Analysis of Infinite Phased Array Antennas with Gaussian Excitation Weightings
H.-T. Chou, *Yuan Ze University, Taiwan*; S.-C. Tuan, *Oriental Institute of Technology, Taiwan*

11:20 305.9 General Analysis of Floquet Modes for an One-Dimensional, Infinite Phased Array Antennas
H.-T. Chou[1], S.-C. Tuan[2], L.-R. Kuo[1]
[1]Yuan Ze University, Taiwan; [2]Oriental Institute of Technology, Taiwan

11:40 305.10 Synthesis of Thinned Uniformly-Excited Time-Modulated Linear Arrays Using an Improved Invasive Weed Optimization Algorithm
R. Bhattacharya, S. Saha, T. K. Bhattacharyya, *Indian Institute of Technology Kharagpur, India*

Wednesday, July 11	8:20-12:00	Huron
Session 306	**AP-S/URSI**	

Electromagnetic Imaging for Breast Cancer Detection

Session Chairs: Susan Hagness, Ovidio Bucci

08:20 306.1 UWB Magnitude Combined Realistic Breast Model Imaging Capabilities
M. Guardiola, L. Jofre, J. Romeu, *UPC, Spain*

08:40 306.2 Microwave Breast Imaging Using an Enclosed Array of Multi-Band Miniaturized Patch Antennas
M. J. Burfeindt, J. D. Shea, A. M. Weiss, N. Behdad, B. D. Van Veen, S. C. Hagness, *University of Wisconsin-Madison, United States*

09:00 306.3 3D Nonlinear Inversion of Realistic Phantoms with Time-Domain Data
G. Chen, M. Ali, M. Moghaddam, *University of Southern California, United States*

09:20 306.4 Average Property Estimation of Breast Tissue: the Use of Time-Gating and Antenna Compensation Techniques
J. D. Garrett, J. Bourqui, E. Fear, *University of Calgary, Canada*

09:40 306.5 Estimation of regional geometric and spatially averaged dielectric properties of an object
D. J. Kurrant, E. C. Fear, *University of Calgary, Canada*

10:00 Break

10:20 306.6 Terahertz Tomography Technique for the Assessment of Breast Cancer Tumor Margins
A. M. Hassan[1], D. C. Hufnagle[2], G. E. Pacey[3,4], M. El-Shenawee[1]
[1]University of Arkansas, United States; [2]Miami University, Unites States; [3]Ohio Wright Center for Innovation (IDCAST), Unites States; [4]University of Dayton Research Institute, Unites States

10:40 306.7 Contrast-Enhanced Microwave Imaging of Breast Tumors Using Sparsity Regularization
F. Gao, B. D. Van Veen, S. C. Hagness, *University of Wisconsin-Madison, United States*

11:00 306.8 Feasibility Study of a Novel Microwave Breast Cancer Imaging Approach Exploiting Magnetic Nanoparticle as Contrast Agents
O. M. Bucci, G. Bellizzi, *University of Naples, Italy*; L. Crocco, C. Ilaria, S. Rosa, *CNR, Italy*

11:20 306.9 Contrast-Enhanced Breast Cancer Detection Using Dynamic Microwave Imaging
M. Klemm, *University of Bristol, United Kingdom*

11:40 306.10 Complex Natural Resonances of Dielectric Objects Embedded in Inhomogeneous Breast Models
F. Yang, A. M. Sanagavarapu, *University of Technology Sydney, Australia*

Wednesday, July 11	8:20-12:00	Michigan A
Session 307	**AP-S**	

Microstrip Circuits I

Session Chairs: Dimitris Anagnostou, George Eleftheriades

08:20 307.1 Design of a Miniaturized Branch Line Coupler Using Common Defected Ground Structure
J. Lim, J. Lee, Y. Jeon, K. Kwon, S.-M. Han, D. Ahn, *Soonchunhyang University, South Korea*; Y. Jeong, *Chonbuk National University, South Korea*

08:40 307.2 A Novel Heptagonal Microstrip Rat-Race Hybrid Coupler with Harmonic Suppression and Size Reduction
W. Song, H. Deguchi, M. Tsuji, *Doshisha University, Japan*

09:00 307.3 Low Loss H-Shape SIW Hybrid Coupler for Millimeter-Wave Phased Arrays Antenna Systems
W. M. Abdel-Wahab, S. Safavi-Naeini, *University of Waterloo, Canada*

09:20 307.4 Exponentially-Decaying Traveling-Wave Resonators by Coupled Positive-Index/Negative-Index Guides
H. Mirzaei, G. V. Eleftheriades, *University of Toronto, Canada*

09:40 307.5 Tunable Bandpass and Bandstop Filter Cascade for Dynamic Pole Allocation
H. H. Sigmarsson, *University of Oklahoma, United States*; E. J. Naglich, J. Lee, D. Peroulis, W. J. Chappell, *Purdue University, United States*

10:00 Break

10:20 307.6 Sectoral Horn Printed Power-Combiner
L. Boccia, A. Emanuele, E. Arnieri, A. Shamsafar, G. Amendola, *University of Calabria, Italy*

10:40 307.7 CCITL Implementation Using Two-Section Microstrip Transmission Lines
S. Limsaengruchi, R. Silapunt, D. Torrungrueng, *King Mongkut's University of Technology Thonburi, Thailand*

11:00 307.8 Design and Analysis of Dual-Band Unequal-Split Bagley Power Dividers
O. A. Abu-Alnadi, N. I. Dib, *Jordan University of Science and Technology, Jordan*

11:20 307.9 Tri-Band Branch-Line Coupler with T-Type and Additional Port Impedance Transformers
F. Lin, Q.-X. Chu, *School of Electronic and Information Engineering,South China University of Technology, China*

11:40 307.10 Design and Analysis of a 3-Way Unequal Split Ultra-Wideband Wilkinson Power Divider
D. F. Hawatmeh[1], K. A. Al Shamaileh[2], N. I. Dib[1]
[1]Jordan University of Science and Technology, Jordan; [2]Waseela for Integrated Telecommunications Solutions, Jordan

Wednesday, July 11	8:20-12:00	Michigan B
Session 308	**AP-S**	

Scattering by Random or Complex Media

Session Chairs: Silvio Barbin, ismail jouny

08:20 308.1 Scattering Features for Target Recognition Using Finite Rate of Innovation Model
I. I. Jouny, *lafayette college, United States*

08:40 308.2 Scattering from an Object above a Rough Surface Using the Extended PILE Method Hybridized with PO Approximation
M. Kouali, C. Bourlier, *IETR, France*; G. Kubické, *DGA Information Superiority, France*

09:00 308.3 Scattering from Spherical Particles with Negative Permeability
Z. Ren, O. M. Ramahi, *University of Waterloo, Canada*

09:20 308.4 Estimation of Side-Hole Location Using Circular Wavefront of Scattering Waves Visualized by Pulsed Laser Scanning
T. Yamamoto[1], H. Tsuda[1], J. Takatsubo[1,2]
[1]National Institute of Advanced Industrial Science and Technology (AIST), Japan; [2]Tsukuba Technology Co., Ltd., Japan

09:40 308.5 Nystrom Solutions of Electromagnetic Scattering by Inhomogeneous Anisotropic Objects
Y. W. Gu, M. S. Tong, *Tongji University, China*

10:00 Break

10:20 308.6 Combined Double Frequency Profiling of Microsrtucture Rain Parameters
A. Linkova, G. Khlopov, O. Voitovych, A. Kogut, G. Rudnev, Y. Belov, S. Khomenko, *Usikov Institute of Radiophysics and Electronics of National Academy of Sciences of Ukraine, Ukraine*

10:40 308.7 A Study of Wave Coefficients as Target Signature for Identification
X. Jiang, *Peking University, China*; M. Xia, *University of Electronic Science and Technology of China, China*

Design of a Miniaturized Branch Line Coupler Using Common Defected Ground Structure

Jongsik Lim, Jaehoon Lee, Yuckhwan Jeon,
Kyunghoon Kwon, Sang-Min Han, and Dal Ahn
Department of Electrical Engineering,
Soonchunhyang University,
Asan, Choongnam, Rep. Of KOREA

Yongchae Jeong
Division of Electronics and Information Engineering,
Chonbuk National University,
Jeonju, Chonbuk, Rep. Of KOREA

***Abstract*— A design of size-reduced 90^o branch line coupler (BLC) is described in this work. A common defected ground structure (CDGS) is adopted to design the coupler. Common DGS patterns are realized on the common ground plane of double-sided microstrip lines of which ground planes are attached to each other back-to-back. The CDGS patterns play a great role in size-reduction of microwave circuits. As an example, a BLC is designed, fabricated and measured at 1GHz for the verification of the size-reduction using CDGS. The size of the fabricated coupler is less than 50% of the normal one without any critical degradation in performances. The measured S-parameters well agree with the simulation results.**

I. Introduction

Recently, microstrip lines having modified ground structures (MGS) such as photonic bandgap (PBG) and defected ground structure (DGS), and their applications to microwave circuits have been studied widely [1-4]. PBG and DGS patterns inserted on the ground plane of transmission lines add the equivalent inductive and capacitive elements to transmission lines, change the characteristic impedances and effective dielectric constant, and produce a slow-wave effect. These properties have been applied successfully to size-reduction and performance improvement of microwave circuits [5,6]. Especially, interest and study for DGS are increasing widely because the equivalent circuit elements are extracted relatively clearly and even a few element show advantages of modified ground structures.

DGS patterns for microstrip lines are realized by etching off a geometrical pattern on the ground plane under the microstrip signal line. However, even the circuit has been reduced with a certain ratio by inserting DGS, the final circuit size still depends on the frequency strongly. Therefore, the effort for miniaturization is again required even after the first try has been done with DGS for relatively low microwave region.

In this work, a common DGS (CDGS) is introduced for double-sided microstrip lines for the purpose of the second size-reduction. The basic idea is shown in Fig. 1. If there is a microstrip line having DGS patterns, it can be folded and become a double-sided microstrip lines of which ground planes are attached to each other back-to-back, so DGS patterns are imposed to both ground planes commonly.

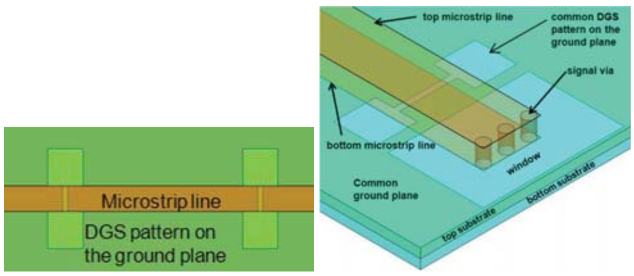
A miniaturized branch line coupler (BLC) is designed using the proposed CDGS, fabricated, and measured as an example in this work. First, previous DGS patterns are inserted to a normal BLC for the first effort to reduce the size. After then CDGS patterns are used for the second try of miniaturization. As the result of design, the circuit size is only around 50% of the normal size due to CDGS.

One of prominent advantages of the proposed method is that it is possible to reduce the circuit size by less than 50% with the performances preserved to be similar or the same. The proposed method will be verified through the measured data.

II. Structure of Common DGS Microstrip Line

Fig. 1(a) shows the microstrip line with dumb-bell shaped DGS patterns on the ground plane realized. Rectangular defects and connecting slot add the equivalent inductance and capacitance to the normal microstrip line, respectively. So the electrical length of the DGS microstrip line is longer than that of the standard line for the same physical length.

If the microstrip line in Fig, 1(a) is folded in order for DGS patterns to be overlapped at the same position, then the DGS is seen commonly by top and bottom microstrip lines as shown in Fig. 1(b). Two signal lines are connected by the several via-holes, called as “signal via”, surround a slot-window which isolates the signal vias from ground plane. The study for signal transition between top and bottom microstrip lines has been done already by Casares-Miranda et al.[7,8].



(a) (b)

Fig. 1 (a) A microstrip line with DGS patterns and (b) 3-d view of the folded microstrip line

III. Design of Miniaturized Branch Line Coupler

Fig. 2(a)~(c) show three branch line couplers (BLCs). Those are normal BLC, size-reduced layout by DGS, and finally miniaturized layout using CDGS. P1 to P4 represent the input, through, coupling, and isolation port, respectively. If the layout in Fig. 2(b) is folded along the vertical center line, then

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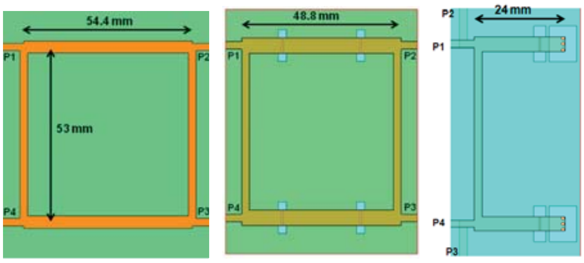
Fig. 2(c) is obtained. For the purpose of simple comparison only by horizontal length, no DGS pattern has been combined with the line between P1 and P4 although it is possible to do so. Obviously, the final BLC in Fig. 2(c) has the smallest size with the ratio of less than 50% from the initial design. It is noted that Fig. 2(a)~(c) well illustrate the advantage of DGS and CDGS serially when they are inserted into microwave circuits.

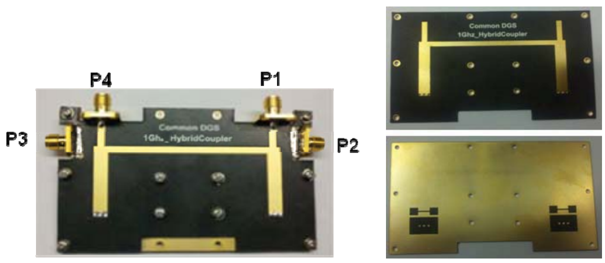
Fig. 3(a) shows the fabricated prototype of the BLC and Fig. 3(b) the top and bottom layouts of the first substrate. The dielectric constant and thickness of the substrate are 2.2 and 31mils, respectively.

Fig. 4 illustrates the predicted S-parameters of the designed BLC. The full-wave simulation has been performed by Ansoft HFSS. Even there is minor shift of center frequency from 1 GHz to 1.06 GHz, the performances well prove that the final design is an acceptable BLC.



(a) (b) (c)

Fig. 2 Branch line couplers at 1GHz (a) normal layout (b) size-reduced one by DGS (c) final design using CDGS



(a) (b)

Fig. 3 Fabricated BLHC using CDGS (a) photo of the circuit (b) photo of the bottom plate of the upper substrate

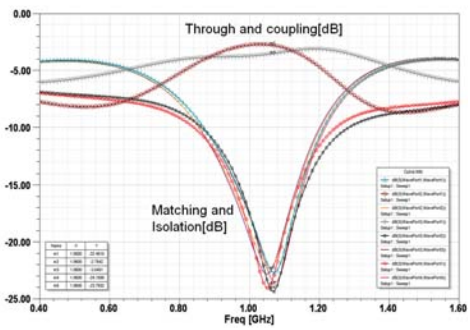
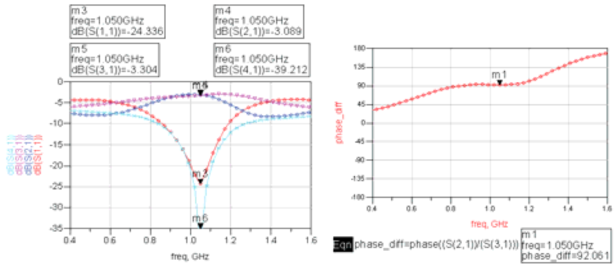


Fig. 4 Simulated S-parameters of the BLHC

Fig. 5(a) and (b) show the measured performances of the fabricated BLC. The measured S21 and S31 are -3.1 dB and -3.3 dB respectively, and the matching and isolation are less than -20 dB. The measured error of the phase difference between port 2 and port 3 is 2.06 degrees. It is seen that the measured S-parameters well agree with the simulated ones.



(a) (b)

Fig. 5 Measured performances of the BLHC (a)S-parameters (b)phase difference

IV. Conclusion

A miniaturized branch line coupler has been designed using a common DGS and double-sided microstrip line. The double-sided microstrip line has been formed by bending the existing long microstrip line and inserting signal vias to connect the signal lines vertically. Common DGS patterns were realized on the common ground plane. The size of the finally designed BLC was less than 50% of the normal one while the S-parameters were well preserved as expectation with a good agreement. It is expected that the proposed design can be well applied to other size-reduced microwave circuits.

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