A Review on Substrate integrated waveguide X and K Band Filter and Power Divider

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Abstract-Substrate Integrated Waveguide Technology (SIW). The dielectric waveform waveguide is converted to SIW with a periodic arrangement of the metallic holes on both sides of the dielectric waveguide. SIW has a high response to the conventional waveguide and periodic projector stripping characteristics. So, filters designed using SIW show fewer losses, lower costs, low weight, high quality factor and high power handling capability.Various passive and active SIW circuits have been studied. The numerical method for modeling and designing SIW components is presented. An SIW has been designed to show insertion losses less than 0.1 dB. Also, design solutions for loss reduction are discussed. It is also discussed the purpose of future design that primarily seeks to integrate substrate systems of SIW components at higher frequencies including microwave.*

Keywords- SIW Components, Band Pass Filter, K and X band Filter, Power Divider, CST

1. Introduction

Integrated Circuits (SIC). The evaluation of the circuit element of the standard circuit theory is not valid at microwave frequencies (ranging from 300 MHz to 300 GHz), because the device dimensions become comparable (or even higher) to the wavelength. Therefore, microwave components are typically treated as distributed elements, where the voltage or current phase changes significantly over the physical length of the device. Consequently, voltages and currents are treated as waves propagating on the device, and propagation effects can no longer be ignored. Micro strip lines are among the most commonly used guide structures at relatively low microwave frequencies due to their simple construction, low cost and high inertia with surface mounting components. A typical band of micro band is formed using a conductor on one side of a dielectric layer with a single table plane forming the other side and air on top.

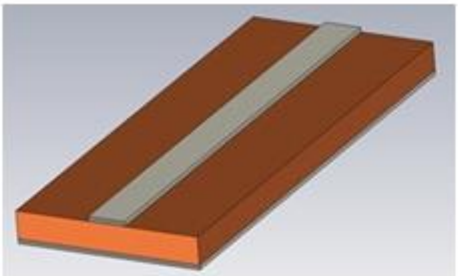

Figure 1.1: Microstrip line

Recently, a hybrid guiding architecture was proposed between micro-band structures and waveguides called the Integrated Substrate Waveguide (SIW) [3]. SIWs are integrated waveforms, such as structures made on dielectric material, with the top and bottom vertices of the side walls being conductors and two linear networks of metallic waveguide structures, an SIW having the characteristics of both, and namely a cost-effective and relatively easy to manufacture process, integrated with flat devices. In addition, it is claimed to function better than the micro-band structures at high frequencies and has the characteristics of the waveguide dispersion [3].

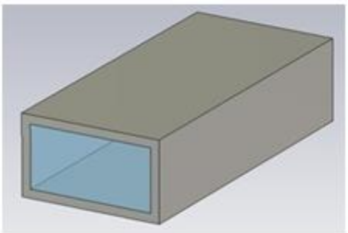

Figure 1.2: Rectangular waveguide

Consequently, a significant number of SIW based microwave components such as filters, couplers, power divider/combiners has been reported so that they can replace their micro strip and/or waveguide counterparts at appropriate frequencies [3]-[65].

A comprehensive review of SIW circuits including the theoretical background with the design equations.

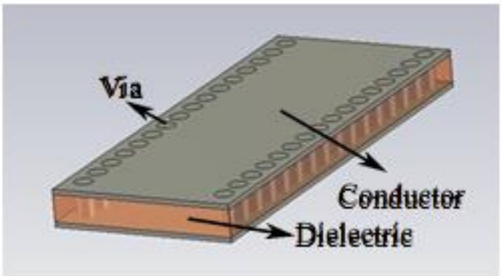

Figure 1.3: Substrate integrated waveguide (SIW)

Integrated substrate waveguides (SIW) are integrated waveforms, such as structures made using two rows of metal plugs embedded in a dielectric that adds two parallel metal plates and these metal rows are form the side walls. This relatively new architecture has the properties of both the micro-band line and the waveguide. Its manufacturing process is also similar to other planned plane architectures. A typical SIW geometry is illustrated in Figure 2.1, where its width (ie separation between the vines in the transverse direction (as)), the diameter of the vias (d) and the step length (p) are the most important geometric parameters (as shown in Figure 2.1) that are used to design SIW structures, as will be explained in the next section. It should be noted that the dominant mode is TE10 as a rectangular waveguide.

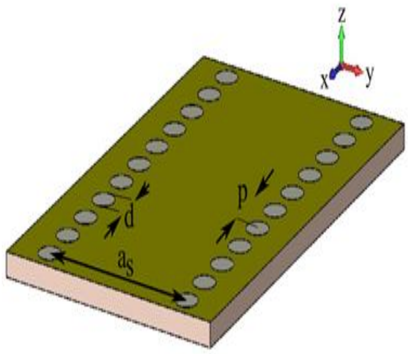

Figure 1.4: Substrate integrated waveguide (SIW)

Substrate integrated waveguide technology can bring some of the performance advantages of waveguide transmission lines to compact micro strip printed circuit boards (PCBs), including filters. To demonstrate some of the promises of SIW technology, a bandwidth was designed for the S-band frequency. By using a SIW-based resonator, we can achieve excellent filtering results in the desired frequency band. The filter has a bandwidth of 2.75 to 3.40 GHz with low bandwidth loss and closely matches the measurements results.

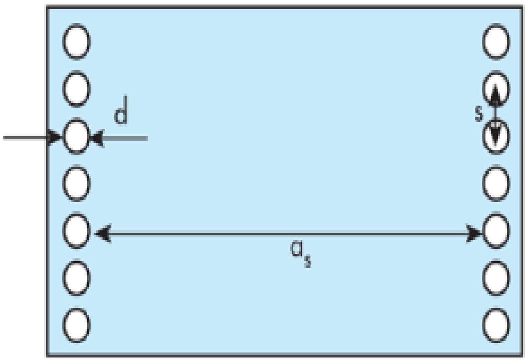

Figure :1.5 SIW topology adoped for the band pass filter.

SIW technology is one of the ways to provide a solution to the high levels of work that represent the smallest and maximum part of a regular rectangular conventional tourism.

SIW technology combines some of the benefits of the function of rectangular traditional waveguides for maximum transmission lines. Benefits of waveguides include low losses, integrated size, high quality (Q), and ability to handle high levels of low electrical radiation (EM). The SIW method allows different components to be constructed and constructed as integrated components using one production process, rather than separately and integrated into sub-sections.

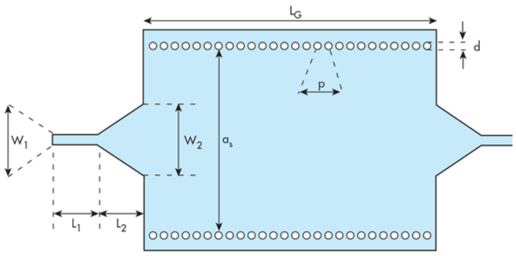

Figure 1.6 siw filter

. This is a top view of the SIW filter, which has following parameters: p = 3 mm; LG = 80 mm; d = 2 mm; as = 51.4 mm; W1 = 2.99 mm; W2 = 19.28 mm L1 = 12.35 mm; and L2 = 12.34 mm.

SIW technology is used to transfer and receive microwave programs and is also suited for researchers and consumers who want to integrate metal waveguides into plane circuits without losing transfer functions. SIW seems to be the promising employer for producing various components and devices in the microwave oven sector.

The SIW concept connects the use of plane micrographs to the operation of a location where the volume mode will be [1]. From a legal point of view, this field contains the lower layer, and the surface and the lower state are described as an iron plane, and the lateral side is defined by an iron line. This vias has a small diameter and distances to appear as electrical walls. However, SIW has been successfully used in the concept of planetary components for microwave applications and millimeter waves. Like couplings [3, 4] and filters, the benefit of this building is of the highest quality and good compatibility.

2. SIW Components and Implementation

The SIW structure consists of two pieces of metal that are periodically coupled to the protective substrate. One of the main emphasis on this program is SIW filters. In the ocean, bank filters can be created by placing irises inside the transfer portion (usually the waves of the waves). Topology is easy to produce and provides excellent places. Only when the air is part of the atmosphere inside the filter.

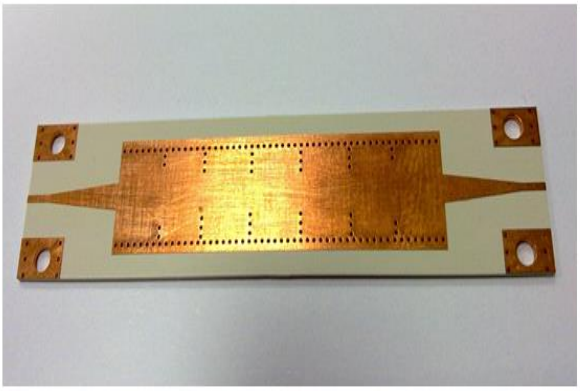

Figure 2.1: SIW iris filter at X-band

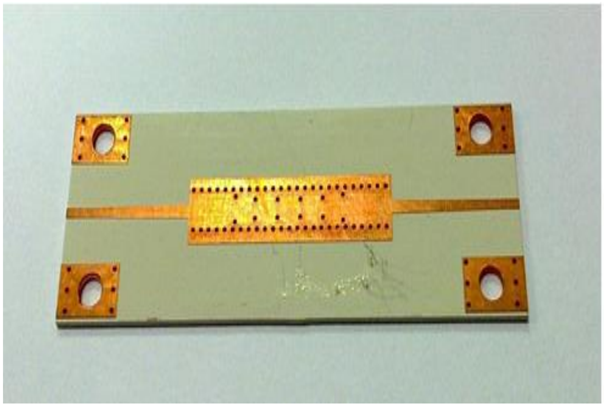

Figure 2.2: SIW iris filter at K-band

The initial state of the design of these filters is performed in a manner similar to an iris filter with an air waveguide. However, after determining the required parameters of the air-waveguide aperture filter, the scale factor is found using the size and SIW parameters of the gas-filled waveguide, and this scale factor is used to determine all of the key parameters of the conductive diaphragm when the filter is fabricated using SIW technology. An aperture placed transversely to the waveguide opening can cause discontinuities and create a parallel reactance. The band frequencies can be obtained from cascaded cavity resonators that combine with these reactive elements that can be created by inserting a series of iris elements within the waveguide. The model consists of an X-band WR-90 waveguide and a symmetric sensing diaphragm (iris).

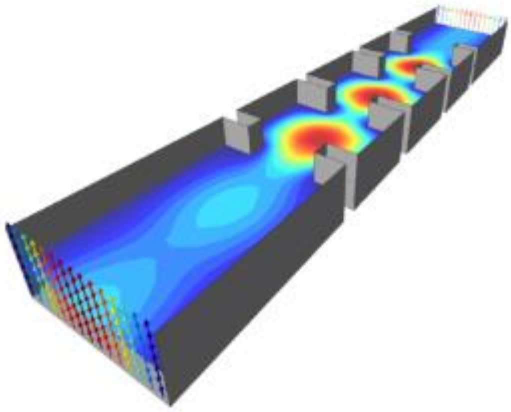

Figure 2.3 Iris band pass filter

The layout contains a series of slot antenna designed for the Ku-band programs. Unlike any recent edition in the field, the result of the submission of the slot has learned more. For a dielectric substrate basic structure is designed with a dielectric constant of 3.2 and a size of 0.782 mm. The design combines the SIW and microstrip antenna in the SIW conversion. Many of the slot categories were read and analyzed using the fully functional CST Microwave Studio simulator, which supports the use of electromagnetic end element (GE). Design is supported by restraint and radiation mode to ensure the performance of the Ku-band. The result of the increase in the number of slot boards was also evaluated to support integration with the system-on-substrate (SoS), which obligation to be structured.

One of the most important feature of microwave used in microwave systems is to divide the power / combiner used to distinguish or consolidate power equally or inequalities (with regard to a specified rating). The three power port connections of port T and Y-junction are the most distinguished. Therefore, the SIW based on energy / integrators have gained prominence in recent years due to their compact size, low weight and higher differential compared to radio power distributors. As a result, different types of SIW power disarming / integration have been distributed previously. Recently, the composition of the integrated waveguide of the substrate (CSIW) has been distributed to [52] and [53], where the stubs open the micro-strip-circuit circuits use vias to build walls on the sides of the SIW. In [52], it is said that the CSIW is compatible with the SIW but allows the integration of active devices. We have proposed the power-sharing CSIW (which is the SIW based on the SIW based power divider) on the X-band. Measuring and measuring results are in harmony with each other and the CSIW power-sharing power displays high resolution.

It is also associated with contacting SIW filter filters. Searches for different SIW band pass filters such as iris type SIW band pass filters in X and K-bands and CSRR uploaded SIW filters on X-band, discussed and compared with DGS uploaded filters. Lastly, the SIW band novels filters a digital type resonator.

Microwave filters are among many groups tested and recognized by SIW devices. As a result, a number of filtering preferences associated with SIW technology have been proposed and various types of bus filing have been made, analyzed and manufactured [21]- [51]. Therefore, in this chapter, we focus on the files of the SIW band pass. As the first part of this chapter, the type iris for SIW filter filters on X and K-bands isbeing investigated. Two prototypes with 10 GHz and 21 GHz centers are designed, revised and made. A good agreement between the estimated and achieved results is available. Therefore, several CSRRs uploaded SIW band pass filters investigated by simulations around 9 GHz. Minimal changes to current writers are designed to raise filter response and reduce production process. Lastly, the SIW filename does not cover the proposed novel. The third-party prototype is designed, revised and manufactured to operate at 9 GHz with a maximum of 500 MHz. The Dumb bel type DGS is used in the lower part of this filter under a small-based nerve line to minimize the next 13.5 GHz high harmonic. A good balance between rating and rating results is available. In addition, the proposed filtering shows good areas of filtering with the best harmonic pressure at 13.5 GHz.

Considering this fact in mind, a SIW based power divider at X-band, proposed in [56], is realized with CSIW where the metallic vias are replaced with open circuit stubs as explained before. The output arms are realized with micro strip lines providing smaller size.

As the first design step, the initial values of the critical parameters for a CSIW structure at X-band are determined. This step is accomplished by synthesizing the structure as a SIW and then converting to CSIW by determining the length and width of the open-circuit stubs. Additionally, the width of the CSIW and the micro strip taper parameters are also optimized for the desired matching at the operating frequency band.

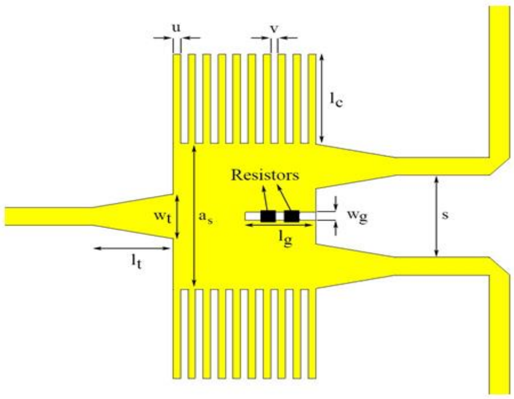

Figure 2.4: CST model of the CSIW power divider

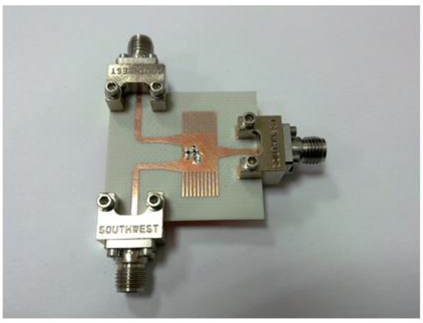

Figure 2.5: Fabricated CSIW power divider

3. CONCLUSION AND FUTURE SCOPE

The latest developments based on the Substrate Integrated Waveguide (SIW) technology presented in the published magazines have been reviewed and explained.Problems related to designing and measuring, as well as the various scientific definitions proposed for the use of the SIW in the current filter and Power Divider. From the available sources, it is observed that most of the conventional rectangular waveguide fed antenna and array structure can be developed by SIW technology. However, most of them work with microwave devices. Balancing, loss, direct production of SIW structures, design limitations and appropriate substrate selection, etc. It seems that components of the SIW utilized in the modern-day system create new opportunities for the development of consolidated integrated systems.

References

[1] Hemendra Kumar, RuchiraJadhav, SulabhaRanade, “A Review on Substrate Integrated Waveguide and its Microstrip Interconnect”, IOSR Journal of Electronics and Communication Engineering (IOSR-JECE), ISSN: 2278-2834, ISBN: 2278-8735. Volume 3, Issue 5(Sep. – Oct.. 2012), PP 36-40.

[2] Cristiano TOMASSONI, Maurizio BOZZ, “Substrate Integrated Waveguide Cavity Filters:Miniaturization and New Materials for IoT Applications”, RADIOENGINEERING,VOL. 26, NO. 3, SEPTEMBER 2017.

[3] SouravMoitra, Asish Kumar Mukhopadhyay&Anup Kumar Bhattacharjee, “Ku-Band Substrate Integrated Waveguide (SIW) Slot Array Antenna for Next Generation Networks”,Global Journal of Computer Science and Technology Network, Web & Security Volume 13 Issue 5 Version 1.0 Year 2013.

[4] BouchraRahali and Mohammed Feham, “Design of K-Band Substrate Integrated Waveguide Coupler, Circulator and Power Divider”,International Journal of Information and Electronics Engineering, Vol. 4, No. 1, January 2014.

[5] Arvind Kumar and S. Raghavan, “A Review: Substrate Integrated Waveguide Antennas and Arrays”, Vol. 8 No. 5 May – August 2016

[6] Ahmed Rhbanou, Mohamed Sabbane, “ Design of K-Band Substrate Integrated Waveguide Band-Pass Filter with High Rejection”, Journal of Microwaves, Optoelectronics and Electromagnetic Applications, Vol. 14, No. 2, December 2015.

[7] Guo Qing Luo, Tian Yang Wang, and Xiao Hong Zhang, “Review of Low Profile Substrate Integrated Waveguide Cavity Backed Antennas”, International Journal of Antennas and Propagation Volume 2013, Article ID 746920, 2013.

[8] Sam Lemey, Frederick Declercq and Hendrik Rogier, “Dual-band Substrate Integrated WaveguideTextile Antenna with Integrated Solar Harvester”, IEEE, 2013.

[9] Ahmad Bakhtafrouz, and Amir Borji, “Compact Two-Layer Slot Array Antenna for K-Band Applications Based on Substrate Integrated Waveguide”, ICEE, 2009.

[10] AmanDahiya, AnandPratap Singh Sengar, Dr. Dhirendra Kumar Dwivedi, Dr.ArunKumar,“A Critical Review of Substrate Integrated Waveguide for Microwave Applications”, Second International Conference on Computational Intelligence & Communication Technology, 2016.

[11] Matthias Steeg,NarutoYonemoto,JonasTebart and Andreas Stöhr,“Substrate-IntegratedWaveguide PCB Leaky-Wave Antenna Design Providing Multiple Steerable Beams in the V-Band”, MDPI, 2017.

[12] W. N. Huang, J. Wu, and Y. J. Cheng, “K-Band Substrate Integrated Array Antenna with Class-3 Antennas RPE (20~24GHz)” of the ETSI Standard Document”, IEEE, 2013.

[13] Muhammad Usman Memon and Sungjoon Lim, “INVITED REVIEW ARTICLE Review of reconfigurable substrate-integrated-waveguide antennas”, Journal of Electromagnetic Waves and Applications, Vol. 28, No. 15, 1815–1833, 2014.

[14] Jan Macháč, “Substrate Integrated Waveguide at Antenna Applications”, 2014.

[15] SitiSabariahSabri,BadrulHisham Ahmad and Abdul Rani Bin Othman,“A Review of Substrate Integrated Waveguide(SIW) Bandpass Filter Based on Different Method and Design”,2012 IEEE Asia-Pacific Conferences on Applied Electromagnetics (APACE 2012), December 11 - 13, 2012.

[16] Tarek Djerafi*,AliDoghri and Ke Wu, Substrate Integrated Waveguide AntennasT, Handbook of Antenna Technologies, 2015.

[17] D. Deslandes and K. Wu, ―Design consideration and performance analysis of substrate integrated waveguide components,‖ in *Proc. Europ. Microw. Conf.*, Oct. 2002, pp. 1-4.

[18] R. Bochra, F. Mohammed, and J. W. Tao, ―Design of optimal chamfered bends in Rectangular Substrate Integrated Waveguide,‖ *IJCSI, International Journal of Computer Science Issues*, vol. 8, issue 4, no. 2, July 2011.

[19] Y. Cassivi, L. Perregrini, P. Arcioni, M. Bressan, K. Wu, and G. Conciauro, ―Dispersion rectangular waveguide,‖ *IEEE Microw. Wireless Comp. Lett.*, vol. 12, no. 9, pp. 333-335, 2002.

[20] K. Wu, D. Deslandes, and Y. Cassivi, ―The substrate integrated circuits-A new concept for high-frequency electronics and optoelectronics,‖*Microwave review*, December 2003.

[21] N. A. Smith, ―Substrate integrated waveguide circuits and systems,‖ Thesis for the degree of Master of Engineering, Department of Electrical & Computer Engineering McGill University Montréal, Québec, Canada, May 2010.

[22] User’s guide – High Frequency Structure Simulator (HFSS), v11.0 Ansoft Corporation.

[23] R. Bouchra, ―Contribution à la modélisationélectromagnétique des structures complexes hyperfréquencesentechnologie SIW, ‖ Thèse de doctorat, Département de GénieElectrique et Electronique, Faculté de Technologie, UniversitéAbouBekrBelkaid de TlemcenAlgérie Mai 2013.

[24] D. Deslandes and K. Wu, ―Integrated Micro strip and rectangular waveguide in planar form,‖ in *Proc. Microwave and Wireless Components Letters, IEEE*, 2001, pp.68-70.

[25] D. Deslandes, ―Design equations for tapered microstrip-to-substrate integrated waveguide transitions,‖ in *Proc. Microwave Symposium Digest, IEEE MTT-S International*, 2010, pp. 704-707.

[26] High-speed data transmission using substrate integrated waveguide-type interconnects,‖ Thesis for the degree of Doctor, Department of Electrical & Computer Engineering McGill University Montreal, Quebec, Canada , February 2009.

[27] Z. C. Hao, W. Hong, J. X. Chen, H. X. Zhou, and K. Wu, ―Single-layer substrate integrated waveguide directional couplers,‖ in *Proc. IEE Proc.-Microw. Antennas Propag.*, vol. 153, no. 5, October 2006.
[28] T. Djerafi,―Etude et réalisation de matrices à commutation de faisceauxentechnologie guide d'ondesintegré au substrat,‖ These de ph.D Genie Electrique, Département de GénieElectriqueEcolePolytechnique de Montreal, April 2011
[29] T. Coenen, ―Analysis and Design of post wall waveguides for applications in SIW,‖ PhD Thesis, the Telecommunication Engineering group of the Faculty of Electrical Engineering, Mathematics and Computer Science of the University of TwenteEnschede, The Netherlands,2010.
[30] W. Q. Che, X. J. Ji, and E. K. N. Yung, ―Miniaturized planar ferrite junction circulator in the form of substrate-integrated waveguide,‖ *International Journal of RF and Microwave Computer Aided Engineering*, vol. 18, no. 1, pp. 8-13, January 2008.
[31] Y. J. Ban, ―Tunable ferrite phase shifters using substrate integrated waveguide technique,‖Département de GénieElectriqueEcolePolytechnique de Montreal Décembre 2010.
[32] S. Germain, D. Deslandes, and K. Wu, ―Development of substrate integrated waveguide power dividers,‖ in *Proc. Electrical and Computer Engineering, IEEE*, pp. 1921-1924, vol. 3, 2003.