Guest Editorial

SPECIAL ISSUE ON SUBSTRATE INTEGRATED WAVEGUIDE DEVICES AND ANTENNAS

A substrate integrated waveguide (SIW) is fabricated by using two rows of conducting cylinders or slots embedded in a dielectric substrate that electrically connect two parallel metal plates. In this way, the non-planar rectangular waveguide can be made in planar form, compatible with existing planar processing techniques (e.g. standard printed circuit board (PCB) or low-temperature co-fired ceramic (LTCC) technology). For such a structure, its propagation characteristics are similar to a classical rectangular waveguide, that is, it has low loss, high quality-factor and high power-handling capability. However, unlike a conventional waveguide, an SIW is easy to integrate components (including passive, active components and even antennas) on the same substrate. It has therefore attracted a lot of attention since its introduction in the late 1990s. Many researchers have conducted original and innovative research in this area. Most noticeably, Prof Ke Wu and his group in Canada have made significant contributions to the development of this technology.

As mobile communication systems are evolving to 5G~~,~~ and millimeter wave frequencies ~~will~~ ~~be~~ are being utilized, it is envisaged that the use of SIWs will become wide-spread. We believe that it is a good time to produce a special issue on this special subject. Since the launch of the Call for Papers, 30 submissions have been received from around the world. After a rigorous peer-review process, 18 papers have been accepted ~~and published~~ for publication in this special issue. As you will see, they cover a wide range of ~~frequencies and~~ devices and frequencies. For convenience, we have divided them into the following three groups: antennas (8 papers), filters (6 papers) and other devices (4 papers).

1. Antennas

There are three leaky wave antenna papers in this special issue. The first paper entitled "*Complex Beam Steering from SIW Leaky Wave Antenna Array*" has used two different antenna structures. The first antenna transmits in the frequency band of 6.9- 11 GHz while the second antenna radiates in the band of 8.9 - 13.8 GHz. The proposed system can continuously steer a single or a dual-beam from -72 to +73 degrees. The second paper is "*SIW Leaky Wave Antenna with Low Cross Polarization in X-Ku Band*". The frequency band is from 9.5 to 15.2 GHz with the X-polarization less than -40 dB. "*A Novel Half Mode Substrate Integrated Waveguide Leaky-Wave Antenna with Continuous Forward-to-Backward Beam Scanning Functionality*" is discussed in the third paper. The antenna scanning region is from -27 to +23 degrees as the operating frequency increases from 10 GHz to 14 GHz.

There are four cavity-backed antennas papers. "*Design and Development a Wideband SIW-based Cavity-backed Slot Antenna using Two Symmetrical Circular Corner Perturbations*" has introduced a new method to improve the impedance bandwidth of a square-shaped SIW cavity-backed slot antenna. "*Substrate Integrated Waveguide Cavity-*

backed Log-periodic Slot antenna For Ku and K band Applications" ~~is to~~ deals with a multi-frequency cavity-backed log-periodic slot antenna. The proposed design has three layers, namely feeding SIW, resonant SIW and Log-periodic slot SIW in order to achieve low loss, high gain and easy integration with high frequency components. The third paper in this group is "*Tunable Slot Antenna Backed by SIW Cavity*" where a cavity backed slot antenna tuned by the integration of three varactor diodes in the radiating slot is introduced. A substrate integrated waveguide cavity backed by an I-shaped slot for broadband application is presented in "*SIW Slot Antenna with Shorting Vias for Broadband Applications*". It was demonstrated that the via loaded cavity-backed SIW antenna has a bandwidth of 21% (10.2 to 12.6 GHz) and a peak gain of 6.05 dBi whereas via loaded half mode substrate integrated waveguide has a bandwidth of 23% (10 to 12.6 GHz) and a peak gain of 6.25 dBi.

The final antenna paper is "*A Beam-Switchable Low-profile Antenna Based on SIW*" where a low-profile pattern reconfigurable printed patch antenna is designed at 2.45 GHz with a height of 1.5 mm. It can generate a total of 12 beams to meet the needs of different application scenarios conveniently.

2. Filters

Six filter design papers have accepted for this special issue. This has been a very active area of the SIW research and development. A series of compact and wideband SIW bandpass filters (BPFs) based on slotlines perturbation have been proposed in "*Compact and Wideband Filters based on Slotline-Perturbed Quarter Mode Circular Cavity SIW*". The proposed filters utilize quarter mode SIW cavities to reduce the profile of 75% comparing with the conventional SIW cavities. Its focus is on how to make the filter compact but wideband – there is normally a trade-off between these two requirements. A novel dual-band highly selective BPF is introduced in "*SIW based dual-band bandpass filter using split ring resonator and defected ground structure for SFCW Radar applications*". The filter is a combination of SIW structure with high-pass characteristic, single rectangular split ring resonators as parallel LC resonator & dumbbell-shaped defected ground structure with band rejection characteristic. The filter has pass band with high rejection values of -15.24dB and -18.43dB and the insertion loss of 0.25~~0~~ dB and 0.36~~1~~ dB at 6 GHz and 8.55 GHz, respectively.

"*Compact QMSIW Bandpass Filter using Composite Right/left-handed Transmission Line in Grounded Coplanar Waveguide*" introduced a new method which is validated by making a fourth-order BPF on a single layer Rogers RO3003 substrate. The measured results demonstrated 14% fractional bandwidth at 8.4 GHz (center frequency), a return loss better than 18 dB and an insertion loss less than 1.55 dB. The paper on "*Self-Packaged Miniature High-order Bandpass Filter for Wideband Applications*" has used an eight-pole bandpass filter as a demonstrator for the design which has achieved a 50% fractional bandwidth with a center frequency of 12 GHz, and an insertion loss of 0.7 dB, including the losses from two connectors.

The final two filter papers are "*Sixteenth-Mode SIW Cavity Filters*" and "*SIW sext-band bandpass filter based on split-type triple-band symmetrical frequency responses*". These two special filters use higher-order modes to achieve desired performance. They are designed, fabricated and measured. The results are in good agreement with the simulated results.

3. Other Papers

In addition to the above antenna and filter papers, there are four other papers. The first one is "*Design of Reconfigurable Integrated SIW Filter and Antenna using Multilayer Approach*". This is a combination of a reconfigurable patch antenna and a filter using the multilayer technique into a single structure in order to realize the integration technique. Design and validation of an equivalent circuit with the varactor diode is presented to study the tunable mechanism. The second paper is "*Characterization of a 4x4 SIW Butler Matrix at 60 GHz for Two-Dimensional Beam Steering*" where an SIW phase shifter that uses periodic rectangular slots is introduced for the first time at 60 GHz to replace the more area-consuming meandered SIW line. The phase shifter prototype, fabricated and measured as a proof of concept, demonstrates achieving an additional 20.3° of phase shift with using only 3 apertures without increasing the length or meandering the SIW line. The hybrid coupler and crossover sections of the SIW Butler Matrix are also optimized to reduce the overall area of Butler Matrix by 53.9%.

"*Extremely Low-Profile Second-Order Bandpass Frequency Selective Surface Using Third Harmonics of Resonant Elements*" is included as the third paper in this group. In this paper, a novel approach for designing extremely low-profile high-order bandpass FSSs is introduced. The structure (similar to SIW) is built by using the coupling of the third harmonics instead of the fundamentals of the resonators to achieve a bandpass response. The thickness of the structure is reduced to one third in term of wavelength when compared with the structure using the fundamental mode. The overall thickness of a second-order FSS can be reduced to $\lambda/75$.

Recently the spoof surface plasmon polariton (SSPP) technique, which is linked to SIW, has attracted much attention for antenna design. The final paper entitled "*A Compact Leaky-Wave Antenna using a Planar Spoof Surface Plasmon Polariton Structure*" is included as a special contribution for comparison with the SIW technology. This paper presents and validates a leaky-wave antenna by using the SSPP technique. By properly designing the unit, the SSPP wave can be switched between the confinement and radiation modes. A large radiation efficiency can be achieved by properly choosing the modulation depth, which ensures that a compact SSPP leaky-wave array can be realized with a small number of SSPP radiation units. The proposed array antenna shows promising capability of the SSPP technique for leaky-wave antenna applications.

Through this special issue, we hope you will learn some of the latest developments in SIW devices and antennas, and their applications.

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