A Dual Band Reconfigurable 64th Mode SIW-Inspired Antenna

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***Abstract*—A compact low profile dual band reconfigurable antenna has been developed and discussed. The basic structure is derived from a circular SIW cavitywhich has been segmented along the quasi-magnetic walls to form the 64th Mode SIW. The ground plane has been engineered to obtain quasi-omnidirectional radiation pattern. The end-wall is shorted by metallic vias. Two locations on the antenna structure have been shorted by PIN diodeswith suitable bias voltages. Dual mode operation at two different frequency bands has been successfully demonstrated.**

Keywords—dual band, reconfigurable, Substrate Integrated Waveguide, 64th Mode, quasi-omnidirectional radiations

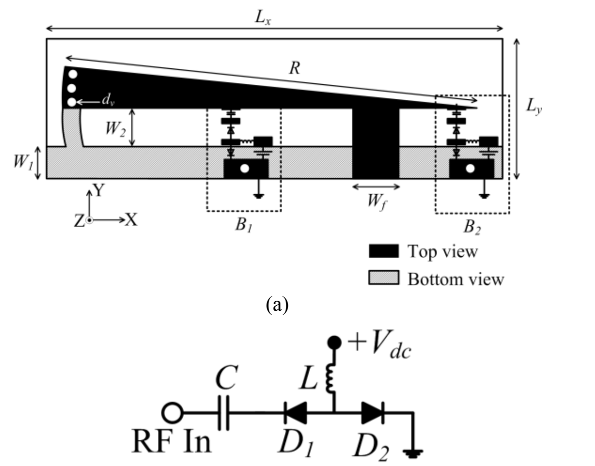
I. Introduction

With the advent of technology, there is an increasing demand for multiband planar antennas, whose frequency can be switched according to the end-user's need as this in turn, reduces the overall transceiver size and eliminates the need of multiple antennas. A few recent works have been reported in [1]—[3] in which reconfigurability of planar antennas have been achieved by the use of PIN diodes.

In the past decade or so, the Substrate Integrated Waveguide (SIW) technology has also established itself as a competent candidate in the efficient design of low profile, compact, planar antennas. Jin *et al* [4] successfully demonstrated the concept of Quarter Mode SIW as a radiator, in which the rectangular SIW geometry was segregated along the fictitious quasi-magnetic wall, while maintaining its frequency of resonance. Lim *et al* could successfully segregate upto the Eighth- Mode [5] and also develop a reconfigurable design on the Eighth- Mode geometry by the use of varactor diodes [6]. As [4]—[6] had considered a rectangular SIW cavity, so they were limited to Eighth- Mode beyond which they could not be segregated.

Overcoming this limitation, Choudhury*et al* [7] could successfully realize and demonstrate the 64th Mode SIW by the use of circular SIW cavity instead of the rectangular cavities as used by the earlier authors. Moreover, the ground plane was tailored to obtain quasi-omnidirectional radiation characteristics.

The present work extends the work of [7] in which a reconfigurable antenna based on 64th Mode SIW- inspired structure has been proposed. Dual bands have been obtained as the antenna is made to successfully operate and switch between 3.35—3.58 GHz and 4.8—5.78 GHz frequency bands by the use of simple PIN diode circuits. Realized gains of 2.95 dBi and 2.7 dBi have been obtained at the two operating frequencies of the antenna.



(b)

Fig. 1. Configuration of the proposedantenna (a) Top and bottom views (Bottom view has been shown by slant lines and vias by white dots), (b) Schematic of Bias circuit (B_1,B_2)
Optimized dimensions: L_x = 55 mm, L_y = 16.2 mm, r = 48 mm, d_v = 0.6 mm, W_1 = 3.5 mm, W_2 = 4.7 mm, W_f= 5.2 mm, h = 1.57 mm, ε_r = 2.2.

II. Antenna Design

The prime motivation of this work is the surface current distributions of TM_{010} and TM_{110} modes for a 1λ current loop in 64th mode SIW geometry. On investigation, the TM_{010} mode shows a current maximum near the central region of the radiator whereas for the TM_{110} mode, the current maximum is towards its pointed end. This promoted the authors to excavate further by grounding the two points individually to separate the two modes. Fig. 1(a) shows the configuration of the proposed Dual Band Reconfigurable 64th Mode SIW- Inspired Antenna with the corresponding optimized dimensions. The antenna has been designed on standard Rogers RT/ Duriod 5880 substrate with thickness (h) = 1.787 mm, dielectric constant (ε_r) = 2.2 and loss tangent (tan δ) = 0.0009. PIN diodes along with the bias circuits (namely B_1 and B_2) have been used in place of metallic shorts to ground the antenna at those locations. Each of the bias circuits comprise of a DC blocking capacitor*C* and a

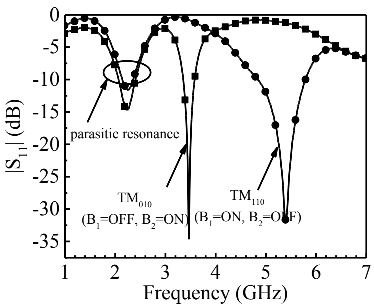


Fig. 2. Simulated reflection coefficient of the antenna with bias applied individually to B_1 and B_2

TABLE I
SUMMARY OF THE SWITCHING STAGES OF B_1 AND B_2

B_1	**B_2**	**Operating Frequency (GHz)**
OFF	OFF	3.35-3.58, 4.8-5.78
OFF	ON	3.35-3.58
ON	OFF	4.8-5.78

radio frequency choke (RFC) L with a provision of DC bias voltageV_{dc} as shown in Fig. 1(b). A pair of PIN diodes (D_1 and D_2) has been used in this particular case to avoid unnecessary shorting of the antenna (which is electrically 'short' at DC due to the conducting vias, shown by white dots in the figure) with the bias circuit. The DC bias is applied to either B_1 or B_2 while the other bias circuit is kept at reverse biasresulting in either TM_{010} mode (B_2 ON, B_1 OFF) or TM_{110} mode (B_1 ON, B_2OFF). A summary of different switching stages of bias circuits B_1 and B_2 are presented in Table I.

The ground plane has been engineered so that quasi-omnidirectional radiation characteristics are obtained from the antenna. Gaps W_1 denote the thickness of the partial ground and W_2, the gap between the ground and the antenna. As one of the open edges of the antenna is nearer to the ground plane, so the coupling of fields from that corresponding edge is more as compared to the edge which is more distant from the ground, but the field patterns retain its modal orientation which has been verified by Eigenmode analysis (not shown).

III. RESULTS

Fig. 2 shows the simulated frequency responses when B_1 is OFF and B_2 is ON (TM_{010} mode) and B_1 is ON and B_2 is OFF (TM_{110} mode). In addition to the required operating frequencies, a parasitic resonance is observed near 2 GHz. It has been verified through simulations that the antenna does not radiate at this particular frequency (not shown) and this can be attributed due to the presence of the lumped elements in the design.

The simulated radiation characteristics of the antenna in xz- and yz- planes for both TM_{010} and TM_{110} modes have been plotted in Figs. 3 and 4, respectively. Both polarizations (horizontal and vertical) which correspond to the fields of the reference antenna have been plotted. From the radiation patterns, it is evident that the antenna radiates quasi-omnidirectionally, which is due to the engineered ground plane. Realized gains of 2.95 dBi and 2.7 dBi have been obtained at the two operating frequencies.

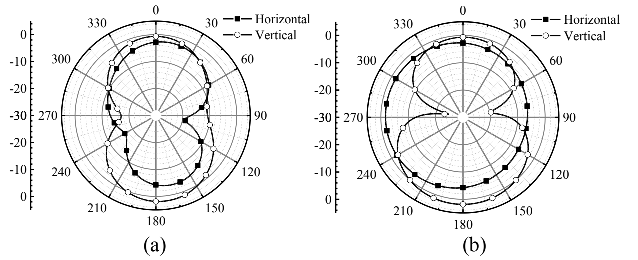


Fig. 3. Simulated radiation pattern (absolute) in (a) xz- and (b) yz- planes for TM_{010} mode

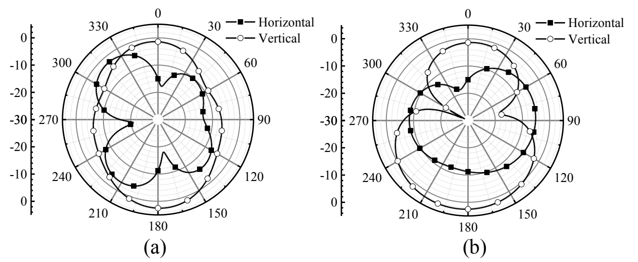


Fig. 4. Simulated radiation pattern (absolute) in (a) xz- and (b) yz- planes for TM_{110} mode

IV. CONCLUSION

A dual band reconfigurable antenna has been explored in the present work. The primary antenna has been designed by repetitive segregation of the circular SIW cavity to reach the 64^{th} Mode geometry. The ground plane beneath the antenna has been engineered to obtain quasi-omnidirectional radiation characteristics. The antenna is made to operate at two frequency bands by alternately grounding at two locations. This antenna can be a potential candidate in transceivers operating in WiMAX– IEEE 802.16 and WLAN– IEEE 802.11, requiring quasi-omnidirectional radiation patterns.

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