CONCEPT OF ELECTRONIC CONTROL OF POLARIZATION RECONFIGURABLE HMSIW U-SLOT ANTENNA

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Abstract: This article deals with a concept of electronic control of polarization reconfigurable U-slot half-mode substrate integrated waveguide (HMSIW) antenna. Switching between left handed circular polarization (LHCP) and linear polarization (LP) is carried out by shorting the slot by two individual PIN diodes. The antenna is designed for the operating frequency of 10 GHz.

Keywords: slot antenna, half-mode substrate integrated waveguide, polarization reconfiguration

1 INTRODUCTION

Thanks to rapid development of microwave wireless applications, antenna with polarization diversity are needed. A polarization reconfigurable antenna can dynamically change its radiating characteristics, thus effectively increasing performance of wireless communication systems.

In this time, only one paper dealing with a polarization reconfigurable antenna based on HMSIW has been proposed. The polarization reconfigurable leaky-wave frequency-scanning antenna based on HMSIW has been proposed in [1]. The antenna consists of a pair of symmetrical +45°/-45° linearly polarized leaky lines and the antenna is feed by 4 ports. Thanks to this configuration, six different polarization states including four linear polarization (LP) states and two circular polarization (CP) are obtained. The antenna is designed for the operating frequency of 21.5 – 23.0 GHz (depending on feeding of the individual ports). The direction of the main lobe is moving from -20° to 20° in both cutting plane. The gain of the antenna is unfortunately unknown.

In [2], we proposed the concept of the polarization reconfigurable half-mode substrate integrated waveguide U-slot antenna radiating LHCP or LP wave. However, the switching between polarizations was not electronically carried out. In this article, we present extension of our work [2] with the focus on the concept of the electronic control of the polarization of the antenna by two a PIN diodes implemented in the slot.

2 CONCEPT OF THE ELECTRONIC RECONFIGURABLE HMSIW U-SLOT ANTENNA

The structure of the antenna is depicted in Fig. 1. It is realized on dielectric substrates ARLON CuClad217 with relative permittivity $\varepsilon r = 2.17$, tangent loss $\tan(\delta) = 0.0009$ and height $h = 1.524$ mm which is on its both sides covered by metal sheets. The HMSIW is created by a row of vias and both its ends are shorted. The HMSIW operates in the fundamental mode TE0.5,0. The radiating U-slot is etched in the top wall of the HMSIW. The shorting strip S1 shorts that slot. To generate left-handed circularly polarized wave, the shorting via V1 is located between the area bounded by the slot and HMSIW bottom wall. The short S2 is substituted by the two PIN diodes with common anode. The diodes are fed by direct current through via V2 (Fig. 2.). In order to the separate direct current from the HF current, the inductor I1 (LQP03TQ2N0B02D) 2 nH has to be used. The self-resonant frequency of the inductor I1 is at 12.5 GHz. If the diodes D1 and D2 (MA4GP907) are turned on, the LP will be obtained, otherwise the LHCP is obtained. The diodes will be glued on the board. The position

of the via V_2 and feeding network of the PIN diodes D_1 and D_2 has small effect to the antenna performance. But it has to be placed on the right side from the slot to avoid heavy deformation of the electric field near the slot. The antenna is equipped by a HMSIW-to-SMA transition.

The antenna was designed with the help of time domain solver of CST Microwave Studio, where local optimizations Trust Region Framework and Nedler Mead Simplex Algorithm were used for the operation frequency of 10 GHz on the dielectric substrate. The resultant dimensions of the antenna are summarized in Tab. 1. The dimensions of the antenna are almost the same in the comparison to the antenna concept proposed in [2]. Only the via V_1 had to be shifted in order to tune antenna at the desirable frequency, because the via V2 and the feeding network of the PIN diodes slightly influences the electric field in the slot.

The distribution of the electric field for LHCP mode is depicted in Fig. 3. Thanks to the shorting via V_1, the electric field at the slot rotates and the left handed circularly polarized wave is obtained in the far field. The distribution of the electric field for LP mode is depicted in Fig. 4. Thanks to the short S_2, the electric field at the slot stops rotating and linearly polarized wave is obtained in the far field.

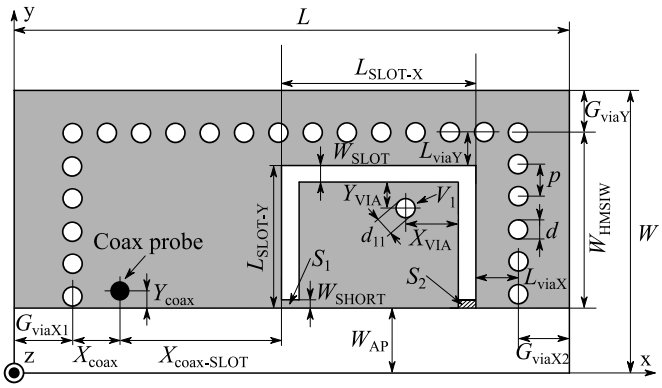

Figure 1: Geometry of the proposed antenna (adopted from [2]).

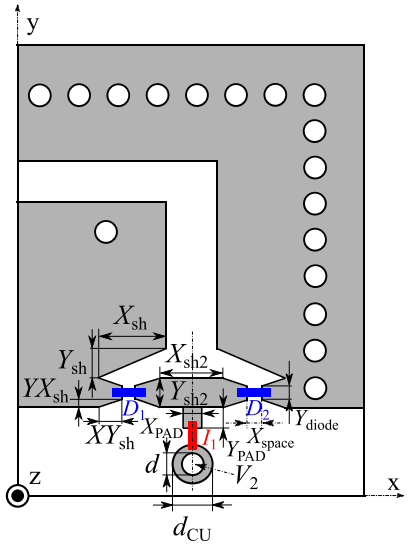

Figure 2: Detail of the short S_2.

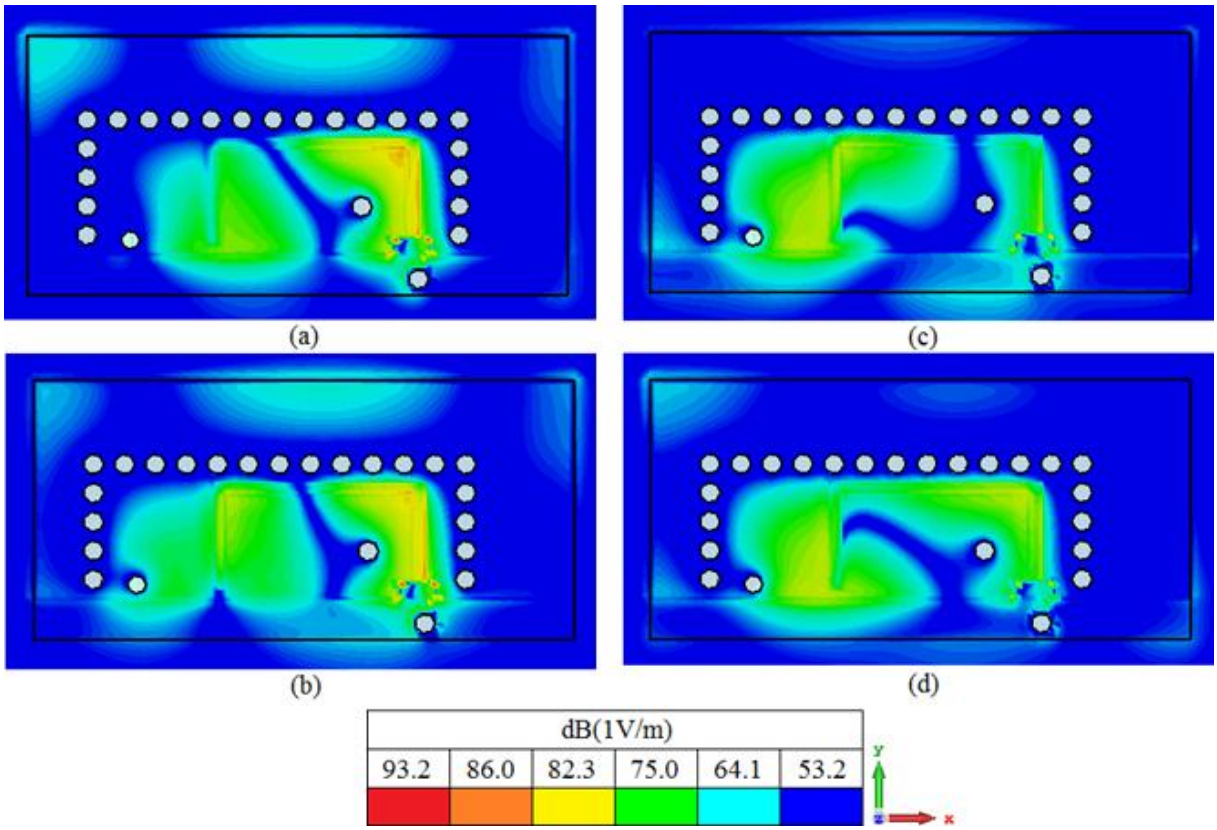

Figure 3: Distribution of electric filed intensity at 10 GHz in the antenna (magnitude) for LHCP mode: (a) phase = 0°, (b) phase = 45°, (c) phase = 90° and (d) phase = 135°.

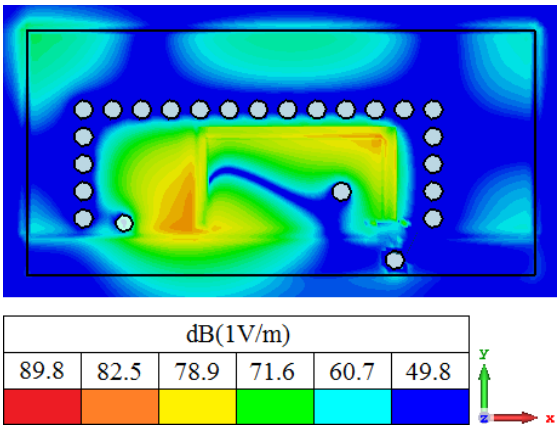

Figure 4: Distribution of electric filed intensity at 10 GHz in the antenna for LP mode.

	[mm]		[mm]
L	37.5	G_{viaY}	5.85
L_{SLOT-X}	14.85	X_{sh}	1.28
L_{SLOT-Y}	8	Y_{sh}	0.4
L_{viaX}	2.8	X_{sh2}	1.53
L_{viaY}	1.15	Y_{sh2}	0.8
W	18	X_{Ysh}	0.385
W_{HMSIW}	9.15	Y_{Xsh}	0.1
W_{SHORT}	0.3	X_{PAD}	0.4
W_{SLOT}	1.1	Y_{PAD}	0.4
W_{AP}	3	Y_{diode}	0.6
X_{COAX}	3	X_{space}	0.33
Y_{COAX}	0.8	d_{CU}	2
X_{VIA}	2.86	d_{11}	1.4
Y_{VIA}	3.79	d	1.4
G_{viaX1}	4.2	p	2
G_{viaX2}	7.5		

Table 1: Dimensions of proposed antenna.

3 SIMULATED RESULTS

In this moment, only simulated results are presented. For the simulation, realistic models of the components (D_1, D_2 and I_1) provided in datasheets were used. In Fig. 5 – 7, there are presented simulated results of the impedance matching, axial ratio (AR) and radiation patterns of the proposed antenna.

The simulated and measured reflection coefficient of the antenna operating in the LHCP and LP mode are depicted in Fig. 5. The measured results for LHCP are about 100 MHz shifted to lower frequencies and measured results for LP are about 400 MHz to higher frequencies in comparison to the simulated ones due to the manufacturing tolerance and discrete components soldered on the dielectric substrate. The measured impedance bandwidth (for s_{11}< -10 dB) of the antenna in the LHCP mode is 25.4 %, and in the LP mode is 12.8 %.

In Fig. 6, the AR of the antenna operating in LHCP mode is depicted. The bandwidth of the axial ratio (for AR less than 3 dB) is 2.75 %. The minimum of AR is 0.84 dB at 10 GHz.

The radiation patterns for the antenna in LHCP mode are depicted in Fig. 7(a). The peak gain of the antenna at 10 GHz is 6.32 dBi.

The radiation patterns of the antenna operating in LP mode are in Fig. 7(b). Th peak gain of the antenna at 10 GHz is 6.67 dBi.

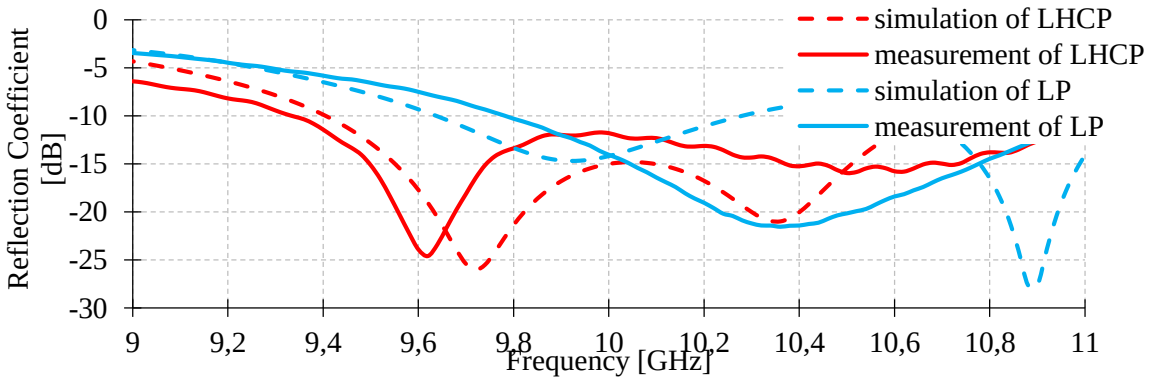

Figure 5: Simulated reflection coefficient of the antenna operating in LHCP and LP mode.

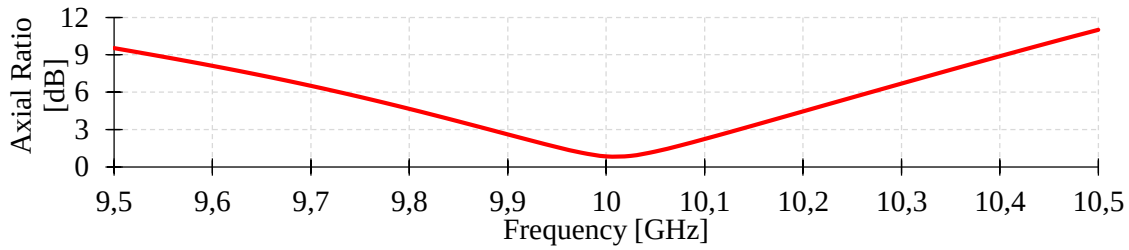

Figure 6: Simulated axial ratio of the antenna operating in LHCP mode.

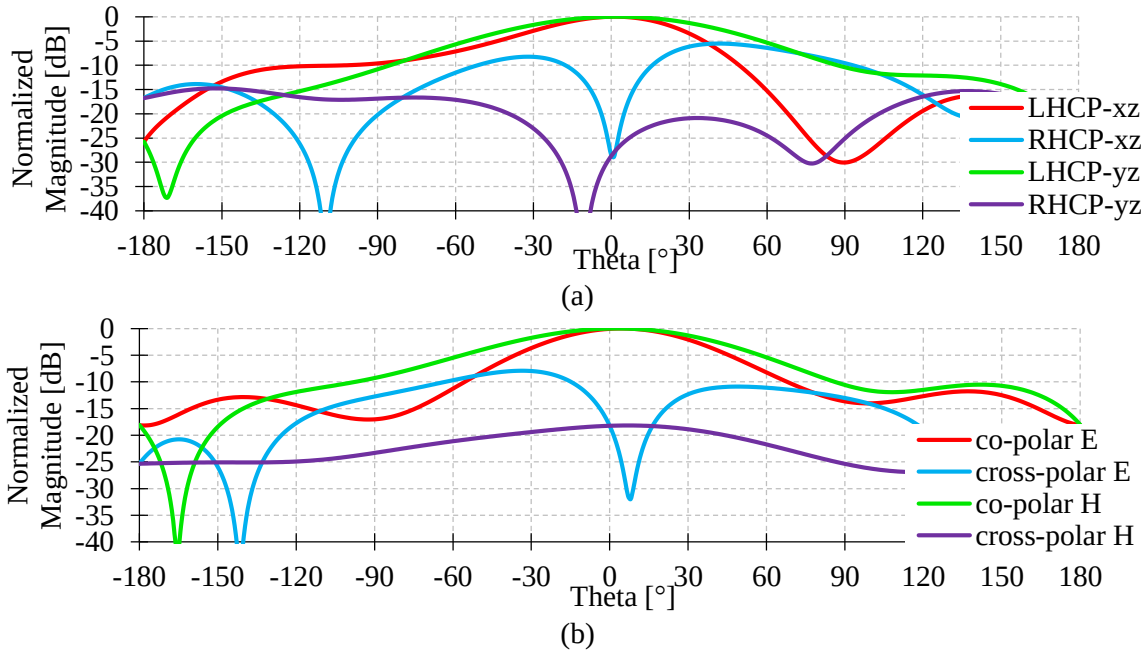

Figure 7: Simulated radiation patterns of the antenna at 10 GHz operating in: (a) LHCP mode and (b) LP mode.

4 CONCLUSION

In this article, concept of the electronic control of the polarization reconfigurable HMSIW U-shape slot antenna [2] operating in LHCP and LP mode has been presented. In this time, only reflection coefficient is measured. The AR and radiations patterns will be measured later. The proposed antenna structure could be exploited e.g. for wireless communication services (after the antenna redesign for a desired frequency band).

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