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Titre : Antenne en réseau Yagi-Uda orientable utilisant une lentille Rotman à guide d'ondes intégré sur substrat

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Résumé : Cet article présente une nouvelle antenne en réseau Yagi-Uda orientable de 8 à 12 GHz utilisant le guide d'ondes intégré sur substrat (SIW). Elle utilise une lentille à guide d'ondes intégrée de type Rotman comme réseau de formation de faisceau (BFN). La lentille micro-ondes proposée est une lentille intégrée de type Rotman réalisée sur un substrat. Un prototype de lentille est conçu avec 7 ports de faisceau, 9 ports de réseau et 8 ports fictifs. Une antenne Yagi-Uda alimentée en SIW de 10 GHz est proposée avec un élément directeur non planaire comme élément rayonnant. Tout au long de cet article, le processus de conception de l'antenne en réseau à phases orientables proposée pour une application de détection de 8 à 12 GHz est démontré en détail.

Mots-clés : antenne en réseau Yagi-Uda orientable, lentille Rotman à guide d'ondes intégré sur substrat, structure de lentille à guide d'ondes intégré sur substrat, réseau de formation de faisceau, BFN, conception de lentille, ports de faisceau, ports de réseau, ports fictifs, antenne Yagi-Uda alimentée en SIW, éléments rayonnants, élément directeur non planaire, antenne en réseau à phases orientables, application de détection micro-ondes, fréquence de 8 GHz à 12 GHz.

A Steerable Yagi-Uda Array Antenna Using a Substrate Integrated Waveguide Rotman Lens

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Abstract— This paper presents a novel steerable 8-12 GHz Yagi-Uda array antenna using substrate integrated waveguide (SIW). It employs an integrated waveguide structure microwave Lens as a beam forming network (BFN). The proposed microwave lens is Rotman type integrated lens in substrate. A prototype lens is designed with 7 beam ports, 9 array ports, and 8 dummy ports. A 10 GHz SIW-fed Yagi-Uda antenna is proposed with nonplanar director element as radiating elements. Throughout this paper, the design process of the proposed steerable phase array antenna for 8-12 GHz sensing application has been demonstrated in details.

Keywords—Substrate Integrated Waveguide (SIW), Beam forming network (BFN), Rotman Lens, Multibeam antenna

I. INTRODUCTION

In recent years, Beam Forming Networks (BFNs) techniques such as Blass, Nolen and Butler matrices, Luneburg, R-KR and Rotman lenses, using substrate integrated waveguides for providing desired far field radiation pattern and pointing direction over the application bands have been developed to produce phased array and array antennas [1]-[9].

II. PHASED ARRAY ANTENNA DESIGN AND RESULTS

The generic block diagram of sensing multi-beam antennas consists of N radiators and M input ports by means of a beam forming network. This paper presents a novel steerable 8-12 GHz Yagi-Uda array antenna using substrate integrated waveguide (SIW) [9]. It employs an integrated waveguide structure microwave Lens as a beam forming network (BFN). The proposed microwave lens is Rotman type integrated lens in substrate. A prototype lens is designed with 7 beam ports, 9 array ports, and 8 dummy ports [2]-[4]. A 10 GHz SIW-fed Yagi-Uda antenna is proposed with nonplanar director element as radiating elements [2]-[4]. The simulated results around the center frequency for X-band application validate the proposed design and scanning capability over $\pm 24^\circ$. The full design process of the proposed phase array antenna is integrated with SIW technology [2]-[4]. In this work, a X-band lens with SIW technology is proposed to feed nine non-planar director Yagi-Uda antenna to generate multiple beams. The proffered steerable array antenna, which is comprised of seven beam ports, eight dummy ports and nine array ports, was designed to operate at the center frequency of 10-GHz, on an RO5880 substrate with electric permittivity of 2.2 and thickness of 0.508 mm [2]-[4]. The proposed Rotman lens

based steerable array antenna is designed for a nine linear non-directive Yagi radiation elements [2]-[4]. Seven beam ports were implemented in the proposed design to steer seven radiating beams at 0° , $\pm 8^\circ$, $\pm 16^\circ$ and $\pm 24^\circ$, respectively. In all previous lenses, the transverse electromagnetic (TEM) propagation incorporated in the design [2]-[4]. One of possible solution for that is to adopt the principle of a non-TEM parallel-plate propagation mode [2]-[4].

III. CONCLUSION

In this paper, a novel 8–12-GHz beam-shaping/steering phased antenna array System using SIW-fed nonplanar director Yagi-Uda antenna is presented.

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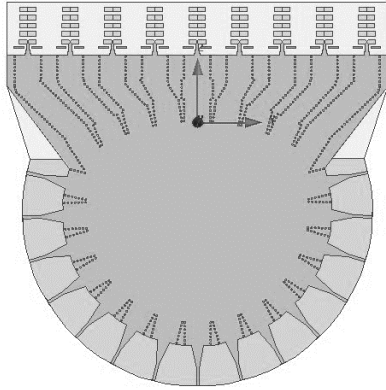


Fig. 1. Geometry of the proposed steerable Rotman lens array antenna

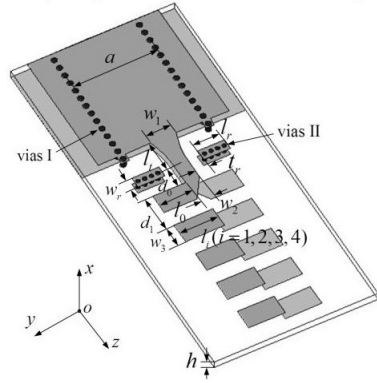


Fig. 2. Geometry of the proposed Single element Yagi-Uda, $a=10.4$, $h=0.508$, $w_1=3.1$, $w_2=1.7$, $r=12$, $d_1=4.6$, $l_0=4$, $l_1=4.75$, $l_2=4.65$, $l_3=4.55$, $l_4=4.45$, $l_5=3.3$ (All in mm).

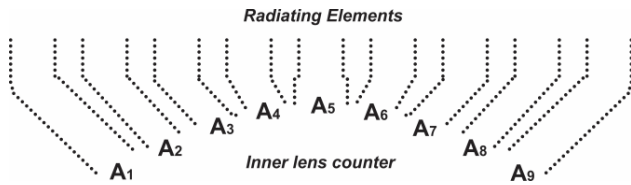


Fig. 3. Geometry of the proposed SIW phase shift network

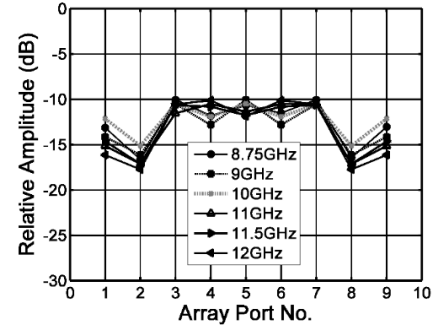


Fig. 4. Relative amplitude distribution across the array ports excited by B_4 beam port (0° beam port) of the SIW Rotman lens at 8.75, 9, 10, 11, 11.5 and 12 GHz, respectively.

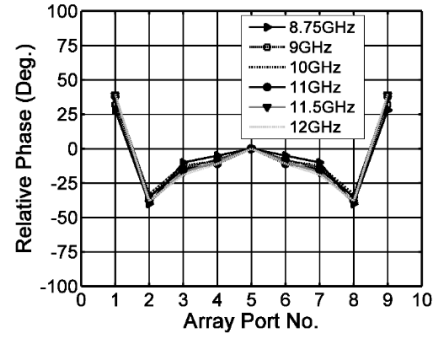


Fig. 5. Relative phase distribution across the array ports excited by B_4 beam port (0° beam port) of the SIW Rotman lens at 8.75, 9, 10, 11, 11.5 and 12 GHz, respectively.

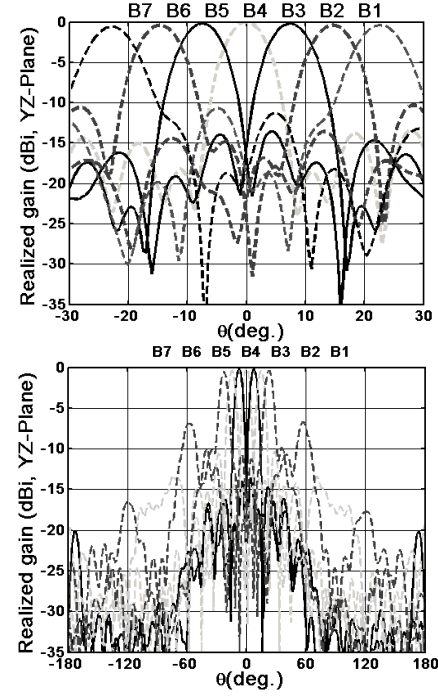


Fig. 6. Simulated 2-D gain patterns spectrum corresponding to B_1 ($+24^\circ$ beam port), B_2 ($+16^\circ$ beam port), B_3 ($+8^\circ$ beam port), B_4 (0° beam port), B_5 (-8° beam port), B_6 (-16° beam port) and B_7 (-24° beam port), beam ports at 10 GHz.

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