A Compact Wideband Substrate-Integrated Waveguide MIMO Antenna for Radar Detecting Application

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Abstract **- In this paper, a compact wideband substrate-integrated waveguide (SIW) MIMO for radar detecting application is proposed. The proposed antenna is a type of two-layer structure comprising of a slotted metallic plate loaded with corrugation structure on the top layer and an FR-4 substrate based SIW on the bottom layer. This antenna satisfies a -10 dB reflection coefficient from 10.15 GHz to 11.58 GHz. To realize the gain enhancement with a narrow beam pattern for radar application, method of constructive superposition of in-phase electromagnetic energy from the two slots is used. In addition, due to the antenna's 2-port characteristic, the proposed antenna also attains beam scanning function from -12˚ to +12˚ from the boresight direction of an antenna.**

Index Terms **— Multiple-input multiple-output (MIMO), compact size, low profile, antenna.**

1. Introduction

Recently, the development of radars as object-detection systems is growing rapidly in diverse fields such as marine radar to locate landmarks and other ships, ground-penetrating radar for geological observations, and range-controlled radar for public health surveillance. For modern radar applications, antennas are required to have compact and low-profile dimensions, wide bandwidth to accommodate multiple standard systems, and high-gain performance synchronously maintaining narrow beam width to improve the radar detection precision. In addition, beam scanning function is also one of the key demands for radar applications. Therefore, there is an essential need to design an antenna possessing multi-characteristic and multi-function mentioned above to apply in radar applications

In this paper, a compact wideband substrate-integrated waveguide MIMO antenna with two paired corrugation structures for radar detecting application is proposed. The proposed antenna operates from 10.15 GHz to 11.58 GHz, which is widely used in military radar system. By properly combining the transversal slot resonance and multimode resonances from SIW cavity, a wideband characteristic is achieved. To acquire gain enhancement with narrow beam width in both E- and H-planes, 2-pair of corrugations loaded on metallic plate and a 2-way 3dB power divider are utilized in this design.

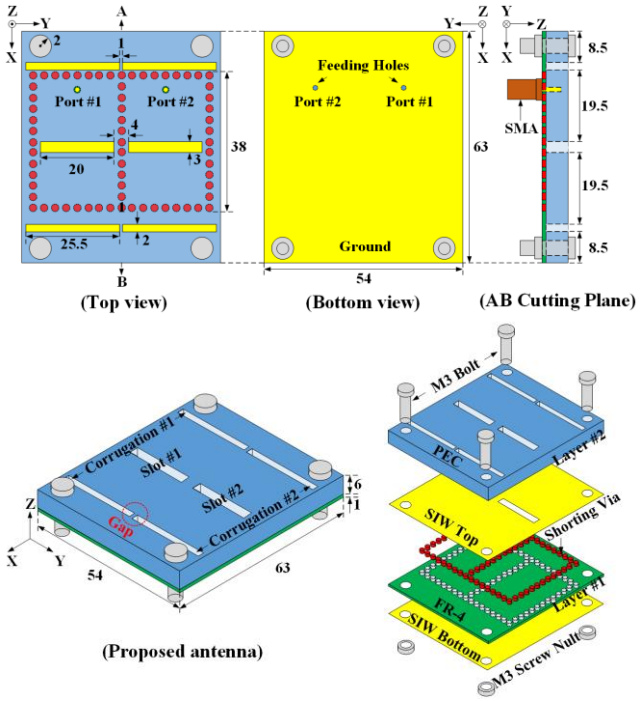

Fig. 1. The proposed antenna configuration (all dimensions are in millimeter).

2. Antenna Design and Results

The proposed antenna configuration is depicted in Fig. 1. The proposed antenna consists of two layers. Layer #1 is an SIW structure [1] designed on an FR-4 substrate (ε_r = 4.4, tanδ = 0.02) with a thickness of 1 mm. The cavity walls in SIW are constructed by using shorting vias with a radius of 1 mm. The distance between the vias is 1 mm. Two transverse slots are loaded at the center of the SIW top plane. Layer #2 is a central double-slotted metallic plate flanked by 2 pairs of corrugations [2]. The proposed structure is fixed by four pairs of M3 bolts and screw nuts made of polycarbonate (ε_r = 2.8, tanδ = 0.01). The antenna is 63 mm × 54 mm with a height of 7 mm. The depth of the two corrugations is 6 mm. This antenna is fed by two 50-Ω SMA connectors from the two feeding holes on the bottom of the SIW.

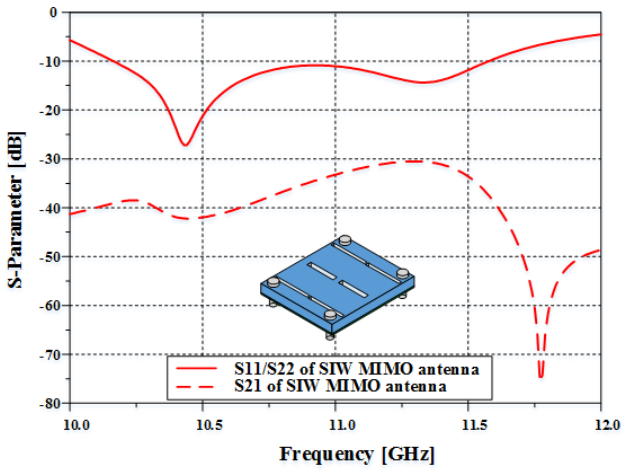

Fig. 2. Simulated S-parameters for the SIW MIMO antenna.

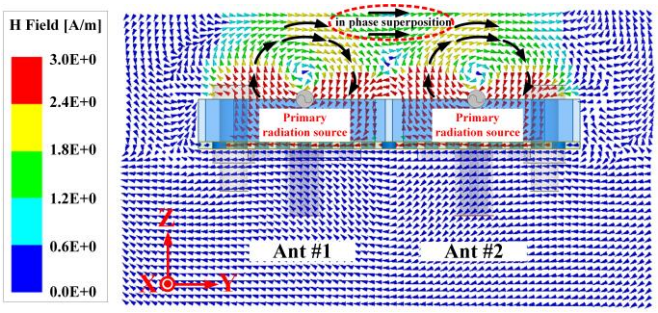

Fig. 3. Simulated H field distribution of the SIW MIMO antenna at 11 GHz.

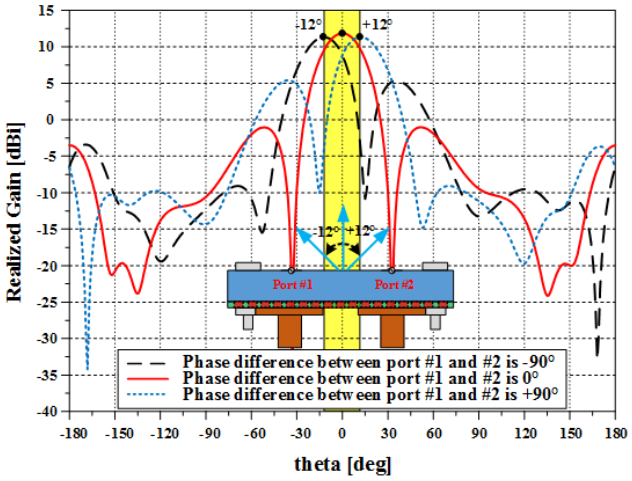

Fig. 4. Simulated radiation patterns for different phases between #1 and #2 at 11 GHz in H-plane.

The excited powers transmit through the slotted cavities in SIW, and the slotted cavities couple their energy to the slotted metallic plate at the top layer. Then, the slotted metallic plate with corrugation structures becomes the main radiator.

Fig. 2 illustrates the S-parameter of the proposed SIW MIMO antenna. The proposed antenna operates from 10.15 GHz to 11.58 GHz with highly isolated performance (S_{21} < -30 dB).

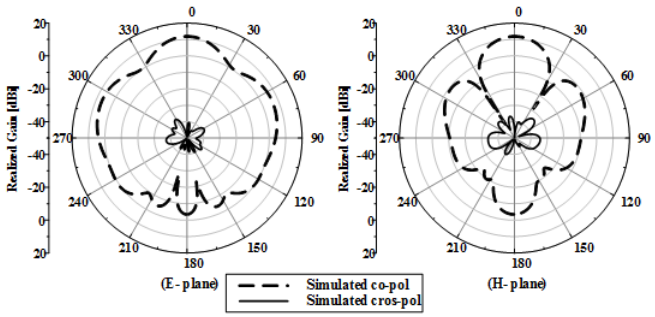

Fig. 5. Simulated radiation patterns for different phases between #1 and #2 at 11 GHz in H-plane.

Fig. 3 shows the H-field distribution of the proposed SIW MIMO antenna at 11 GHz. It is observed that due to the in-phase superposition of the H-fields from the two single port antennas (Ant #1 & Ant #2), the more directive beam is obtained.

Fig. 4 shows the simulated radiation patterns for different phases between port #1 and #2 at 11 GHz in H-plane. This figure shows that the proposed antenna attains beam scanning capability from -12˚ to +12˚ from antenna boresight direction.

Fig. 5 shows the simulated radiation patterns at 11 GHz both in E-and H-planes. The proposed antenna has a peak gain of 11.8 dBi. The HPBWs of the proposed antenna are 28.7˚ in E-plane and 27.6˚ in H-plane, respectively.

3. Conclusion

In this paper, a compact wideband 2-port substrate-integrated waveguide (SIW) antenna with a central double-slotted metallic plate flanked by 2-pair of corrugations for radar detecting application is proposed. The proposed antenna attains good radiation gains greater than 7 dBi over the operating frequency band. The antenna realizes low-profile, wideband, narrow beam width both in E- and H-planes in spite of its compact size. In addition, this antenna equips the beam scanning ability. Therefore, the proposed antenna is a good candidate for radar application.

Acknowledgment

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References

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