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Compact CPW-fed bow-tie and triangle slotted antenna with wide impedance bandwidth characteristics

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ABSTRACT

A coplanar waveguide (CPW) fed printed antenna with a Bow-Tie and a triangle slot is proposed. The antenna consists of loaded stub inside the Bow-Tie slot area. A prototype of the antenna for working at 1.7GHz to 2.6GHz band fabricated and measurements conducted too. The proposed antenna provides wideband characteristics with almost 50% bandwidth (1.7 GHz to 2.6 GHz) around the centre frequency of 2.15 GHz. In addition to wide impedance bandwidth of the antenna its size has kept as small as possible to satisfy the compact size requirements. Conducted measurements for reflection coefficient (S11) and radiation pattern validate our simulation results.

1. Introduction

Printed microstrip slot antennas have been used in many wireless communication systems because of their small size, low profile, light weight, low cost and simplicity of the structure, installation and fabrication (Moosazadeh and Kharkovsky, 2014; Sung, 2012; Luo et al., 2013). These types of antennas easily can integrate with monolithic microwave integrated circuits (MMICs) and provide stable radiation patterns (Lin et al., 2013; Volakis et al., 2010). On the other hand, patch antennas are known that they have narrow bandwidth. According to the literature, varieties of methods have been used to improve the bandwidth of patch antennas such as gap coupling (Kandwal and Khah, 2013), using an asymmetric dual-branch feed (Liu et al., 2013), embedding types of slots (Chao-Ming et al., 2012; Shafiei et al., 2015; Shafiei and Roslee, 2009), using parasitic structures inside the slot (Ojaroudi and Ojaroudi, 2013), magnetic ground plane (Yang et al., 2013) and parasitic patches (Fan et al., 2012).

Therefore by using a proper geometry for the antenna structure, large bandwidth is achievable (Azim et al., 2013). One of the wideband antenna geometries that they have reported in many publications are the bow-Tie antenna. In addition, the type of feeding is an effective feature for bandwidth characteristics of the antenna. Indeed there are some reported Bow-Tie antennas that they have fed by coaxial line (Daotie and Jun-Fa, 2012; Shi-Wei, 2013; Shi-Wei et al., 2008), coplanar waveguide (Hadarig et al., 2010; Wusheng et al., 2013) and stripline (Hao et al., 2013; Sayidmarie and Fadhel, 2013).

The Bow-Tie antenna has been used in many applications such as imaging (Yurduseven et al., 2013), ground penetrating radars (Faraji et al., 2009), WiFi access (Kaswiati and Suryana, 2012), and pulse antennas (Lestari et al., 2004). In addition, it satisfies our requirements for having a low profile antenna with large bandwidth characteristics, high radiation efficiency and ease of fabrication.

Simple structure antenna can be realized by means of microstrip line feeding structure or coplanar waveguide (CPW) feeding structure (Mandal and Das, 2013). This feeding structure next to the single sided printed antenna provides an easy means of fabrication and installation for the antenna. CPW feeding structure facilitates matching and gain improvements by easy parallel and series connections. CPW-fed printed slot antenna provides easy means of integration with Monolithic Microwave Integrated Circuits (MMICs) (Simons, 2001; Smith et al., 2013) in addition to its

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advantages for demonstrating the wider bandwidth as well as less radiation loss and less dispersion (Eldek et al., 2004; Mandal and Das, 2013).

In this paper, a CPW-fed antenna is presented which consists of two slots; Bow-Tie and triangle. Inside the Bow-Tie slot a stub and load have embedded. The antenna prototype is built on a single side of a printed circuit board (PCB) and directly matched to the 50Ω SMA connector.

The antenna is carefully analysed in terms of the reflection coefficients, voltage standing wave ratio (VSWR) and Radiation pattern in working frequency band. The analysis and assessment of the antenna is performed by means of the CST Microwave StudioTM. The measurement results of the proposed antenna prove the validity of our simulations.

2. Antenna design and fabrication

CPW-Fed loaded stub is embedded inside a Bow-Tie slot area and there is a triangle slot on top of that to comply with our desired performance and characteristics. Alignment is a problem during fabrication of the double sided printed antennas. The problem can be solved by having the structure on one side of the substrate. The CPW-Fed is such a feeding line that can provide a single sided structure. This feeding type provides lower loss in comparison with the microstrip line feed. The proposed geometry is shown in Fig. 1. The parametric design of the antenna provides more degrees of freedom for tuning purposes during simulation to achieve proper results (Fig. 2).

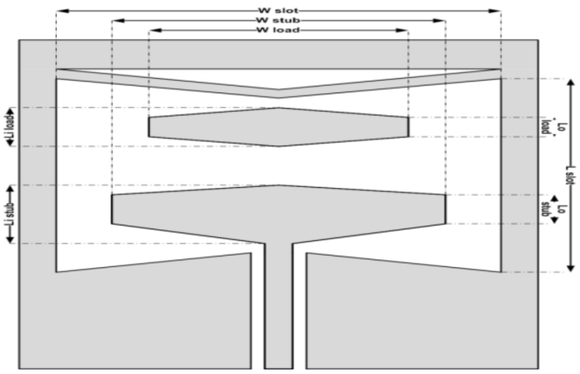

Fig. 1: Designed geometry

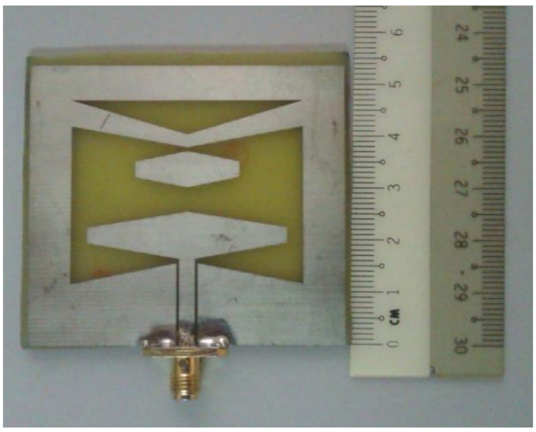

Fig. 1: Fabricated antenna

The dimensions of the antenna have been formed by variables that define the size and geometry of the antenna. The fabricated values are as follows: (All sizes are in millimetre)

Wslot: 44 Wstub: 32 Wload: 20
Lslot: 32 Listub: 8 Liload: 7
Lostub: 4 Loload: 3

The proposed antenna has only one side fabrication which makes the antenna easier for fabrication and integration. Fig. 1 presents the fabricated antenna. For the fabrication board we used copper coated FR4 material. The relative permittivity (εr) of the fibre is 4.3 and it has 1.6 mm thickness.

3. Results and discussion

3.1. Return loss

One of the most important characteristics of the antenna is return loss. Fig. 2 presents reflection coefficient for the designed antenna in both simulation and measurement. The reflection coefficient of the feed port expresses the amount of return loss happened due to the port mismatch. As long as the S11 is lower than -10dB line, the return loss is acceptable and it determines the working frequency band of the antenna. The measurement presents lower bandwidth than simulation but it still covers our desired frequency band from 1.7GHz to 2.6GHz.

3.2. VSWR

Reflection coefficient can express voltage standing wave ratio (VSWR). The simulation and measurement results for the VSWR demonstrated in Fig. 3. It describes the power reflected from the antenna input port.

$$VSWR = \frac{1+|S_{11}|}{1-|S_{11}|}$$

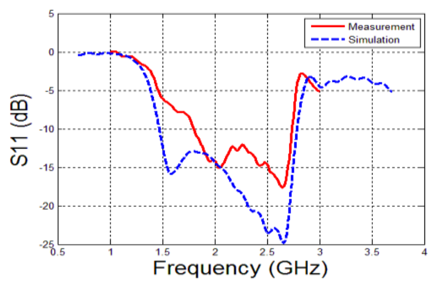

Fig. 2: Return loss - measurement VS simulation

3.3. Radiation pattern

The free space E-plane and H-plane radiation pattern have been measured for frequencies of 1420MHz, 1500MHz, 2100MHz and 2600MHz and shown in Fig. 4, Fig. 5, Fig. 6 and Fig. 7 respectively.

The solid line and the dash line are co-polarized and cross-polarized components, respectively.

It was expected to have smaller amplitudes at 1420MHz and 1500MHz, because the higher amplitude for the radiation pattern is expected when the VSWR is less than 2.1. Indeed, the better performance for the radiation pattern is achievable at lower VSWR.

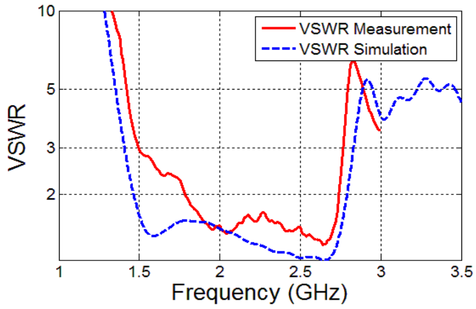

Fig. 3: VSWR - measurement VS simulation

It can be observed from the radiation pattern graphs that the antenna exhibits approximately omni-directional radiation patterns for H-plane. Because the wavelength is much larger than the antenna size at working frequencies, the radiation pattern in E-plane is nearly close to symmetrical.

The electrical length of the antenna increases at higher frequencies but the some asymmetry shapes in the radiation pattern happens by the CPW feeding structure. At higher resonant frequencies this effect becomes less than lower resonant frequencies. When the frequency increases, higher order harmonic introduces to patterns and consequently the pattern shapes become more directional. The measured radiation patterns of the antenna are similar to those of a typical monopole antenna.

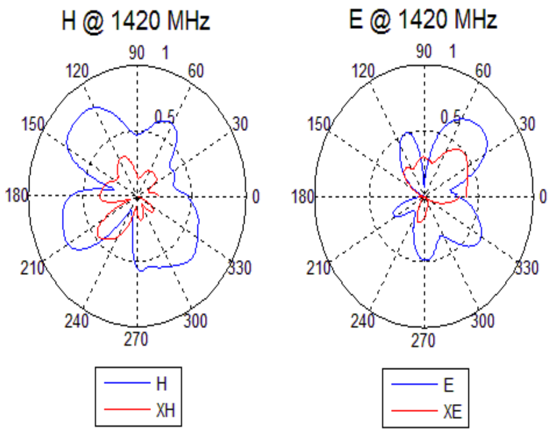

Fig. 4: Radiation pattern @ 1420 MHz

4. Conclusions

The paper proposed a CPW-Fed printed antenna width a Bow-Tie and a triangle slot. The stub and the load are embedded inside the Bow-Tie slot area and all together provide a single sided planar geometry. The designed antenna provides more than 50% bandwidth around the center frequency of 2.15 GHz. The frequency band is from 1.7 GHz to 2.6 GHz.

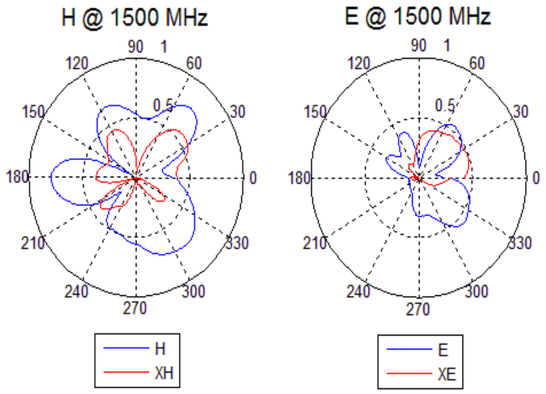

Fig. 5: Radiation pattern @ 1500 MHz

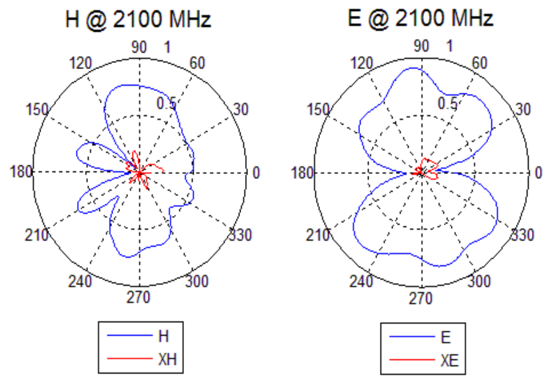

Fig. 6: Radiation pattern @ 2100 MHz

CPW-Fed structure provides wider bandwidth with lower dispersion in comparison with Probe-Fed and Microstrip Line-Fed antennas. This characteristic is desired for many applications. Unipolar configuration of the single sided CPW-Fed antenna is easy to be implemented. Also fabrication and integration of this structure is easy. This kind of printed antenna complies with the requirement of small size and light weight, so it is very useful for portable systems. Because of using FR4 substrate and simple structure the antenna is very low cost. Bow-Tie geometry provides radiation characteristics similar to rectangle antenna, but smaller size. The results are proven through simulation, fabrication and measurement.

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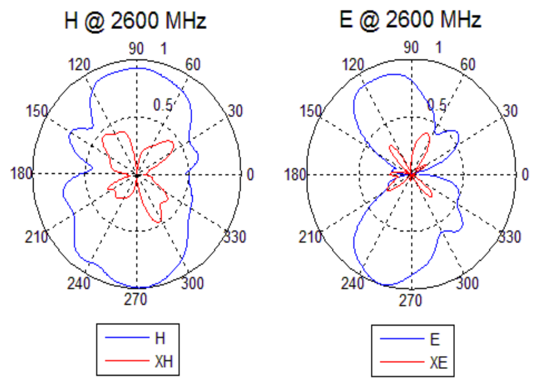

Fig. 7: Radiation pattern @ 2600 MHz

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