A Bowtie Antenna Using a Broadband Microstrip to CPS Transition Balun

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Abstract— In this paper, a bowtie antenna using a broadband microstrip to coplanar stripline transition balun is proposed. This antenna with a new transition structure has several advantages such as small size, wide bandwidth, and good impedance matching. In the balun of this antenna, the low impedance of the mircrostrip lines is gradually transformed to the high impedance of the CPS by a tapered bottom strip line. The proposed antenna was designed and fabricated on Teflon substrate for bandwidth from 2.2 GHz to 6 GHz. The measured return loss is less than 10 dB from 2.1 GHz to 6.5 GHz. The measured gain is from −4.5 dBi to 2.4 dBi.

1. INTRODUCTION

Patch antenna is widely used in wireless communication because of its advantages, such as low profile, low cost and easy fabrication. Especially, a wideband dipole patch element is used to obtain the performance of wideband and omnidirectional radiation pattern in this planar structure. A patch dipole element of a bowtie shape offers good performances in the bandwidth and radiation pattern. By the way, this bowtie patch has to be fed by a suitable feeding network to satisfy the requirement.

A microstrip to coplanar stripline (CPS) transition balun has been used commonly used as feeding networks in this kind of antenna design. Various structures of microstrip to CPS transitions have been reported [1–4]. There are widely used two structures to provide RF continuity between the CPS strip and microstrip ground plane as follows. One of them is the transition structure via directly electrical contact and the other is the method using electromagnetic coupling between two different layers. However, the former structure has the drawback due to the fabrication of several via holes and the latter requires large surface area for sufficient coupling.

In this paper, a new wideband microstrip to CPS transition structure to solve the above problems is introduced and broadband bowtie antenna using the transition balun is designed. The proposed antenna was optimally simulated and fabricated on Teflon substrate for bandwidth from 2.2 GHz to 6 GHz.

2. ANTENNA DESIGN

Figure 1 shows a configuration of the proposed microstrip to CPS transition balun. In this structure, the electric field distribution of the microstrip line as unbalanced transmission line is transformed to one of CPS as a balance one by using a via-hole and a tapered ground line on the bottom plane. In addition, the low impedance of the mircrostrip lines is gradually changed to the high impedance of the CPS. We can achieve electrical contact between two different layers by only one via-hole in this transition.

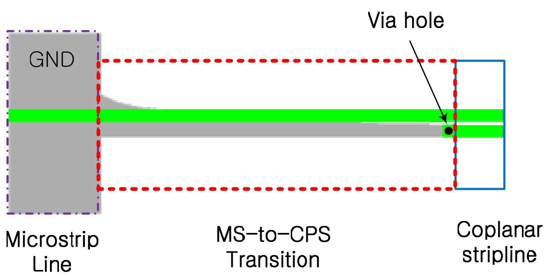


Figure 1: Configuration of the proposed microstrip to CPS transition balun.

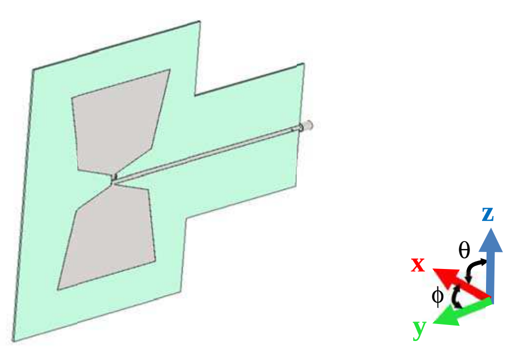


Figure 2: Designed bowtie antenna with the proposed balun.

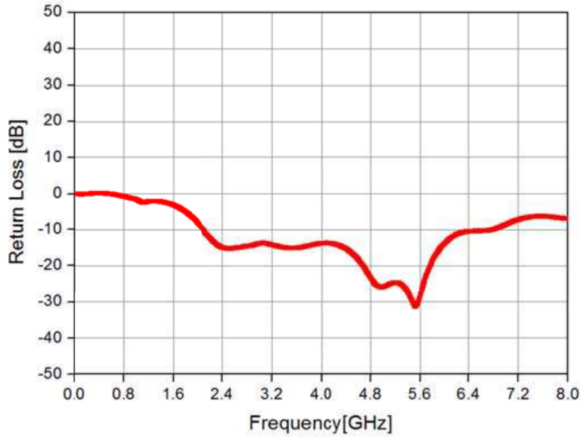
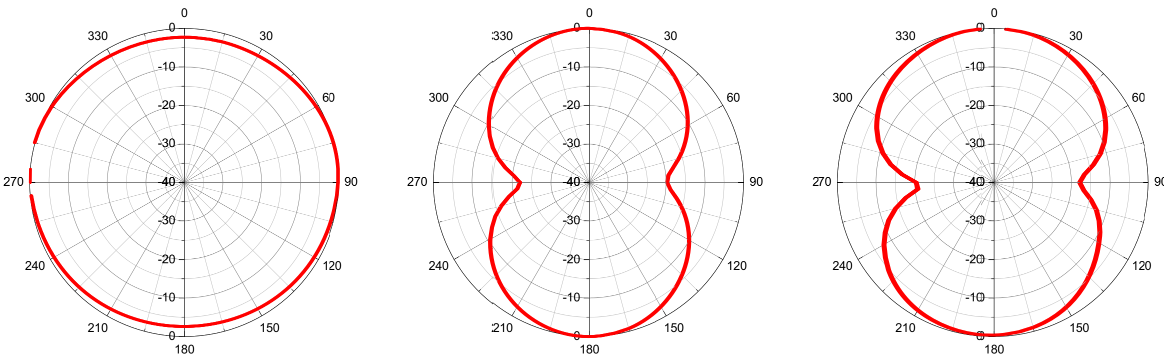


Figure 3: Return loss of the designed antenna.



(a) (b) (c)

Figure 4: Radiation pattern of the designed antenna. (a) Azimuth ($\theta = 90°$). (b) Elevation-1 ($\varphi = 0°$). (c) Elevation-2 ($\varphi = 90°$).

The designed bowtie antenna using the proposed transition balun is presented in Figure 2. This antenna is designed to operate from 2.2 GHz to 6 GHz. The dielectric substrate is used as that with a dielectric constant of 3.5 and a thickness of 20 mil. The size of antenna is 73 mm $(W) \times 91$ mm (H). In this design, the impedance of microstrip line is 50 Ω and the characteristic impedance of CPS is 120 Ω. The width of the microstrip line is 1.1 mm and the strip width and gap of the CPS are 1.1 mm and 0.2 mm. And the bottom ground line of the microstrip line is tapered to match the impedances between the microstip line and the CPS one.

Figure 3 shows the simulation result for return loss of the designed antenna. In this result, the simulation result is less than 10 dB from 2.1 GHz to 6.5 GHz.

In Figure 4, the simulation results of radiation patterns for the proposed antenna are shown. Figure 4(a) azimuth pattern, and Figure 4(b) and Figure 4(c) are elevation patterns. From these results, we can know that the designed antenna has omnidirectional pattern.

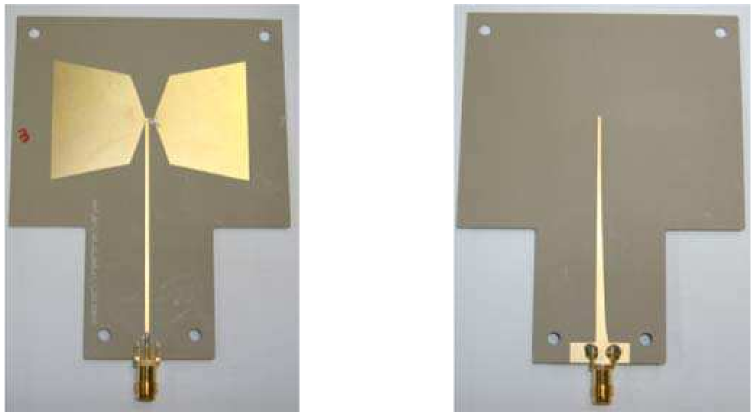
3. RESULTS AND DISCUSSIONS

The proposed antenna is fabricated on RF-35 substrate, and fed by SMA connector. Figure 5 is the photograph of the fabricated antenna using the proposed transition balun.

Figure 6 shows the measured results for return loss of the fabricated antenna. From the result, we can see that the measured return loss is similar to above the simulated result. The measured result is less than 10 dB from 2.1 GHz to 6.5 GHz.

Figure 7 shows the measured gain. The measured gain is $-4.5 \sim 2.4$ dBi from 2.2 GHz to 6 GHz.

Figures 8(a) and 8(b) are the photographs of the measurement environment. This measurement system is installed in 10-meter-long 3D anechoic chamber. Figure 8(a) is the transmission antenna and Figure 8(b) is the fabricated antenna.



(a) (b)

Figure 5: Fabricated bowtie antenna with the proposed balun. (a) Top view. (b) Bottom view.

Figure 6: Measured return loss of the fabricated antenna.

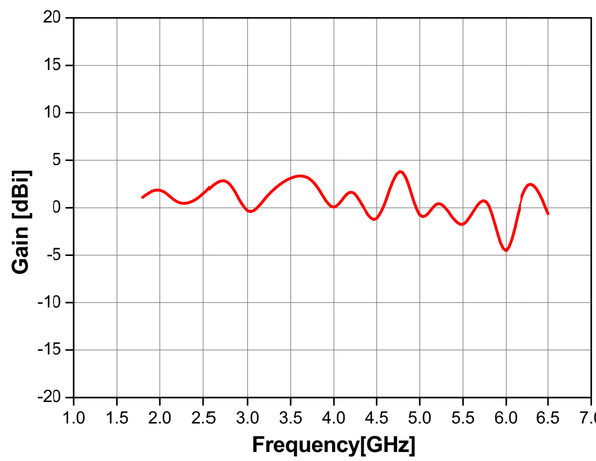
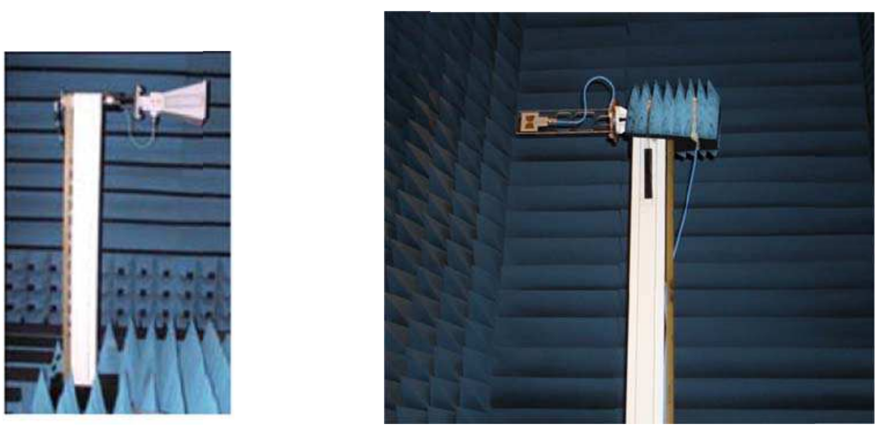


Figure 7: Measured gain of the fabricated antenna.



(a) (b)

Figure 8: Fabricated antenna which was installed in the anechoic chamber. (a) Transmission antenna. (b) Fabricated antenna (AUT).

In Figure 9, the measured results of radiation patterns for the proposed antenna are shown. From this result, we can see that the measured results are similar to the simulated results of Figure 4 but are distorted slightly. That difference results from measurement environment, such as measurement jig, RF cable, and mast.

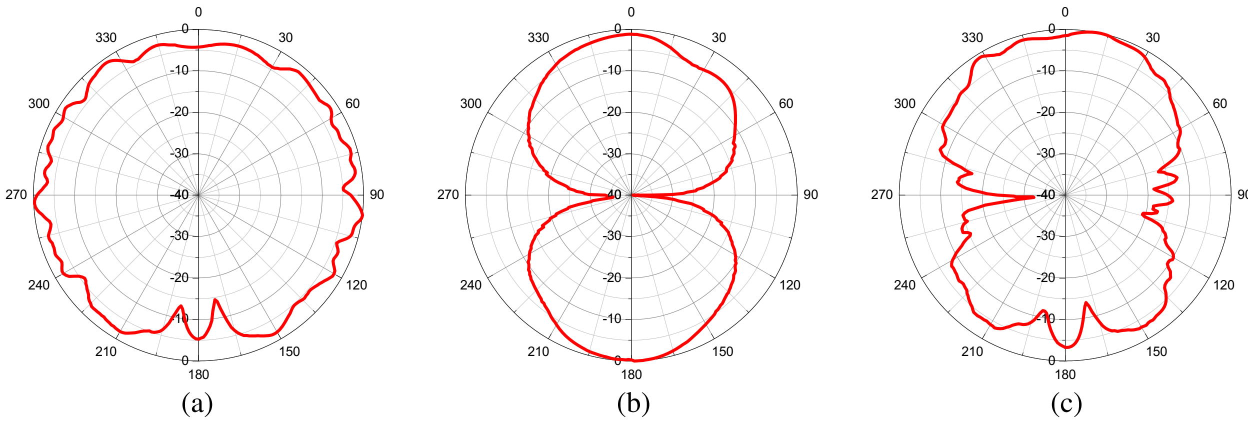


Figure 9: Measured radiation pattern of the designed antenna. (a) Azimuth ($\theta = 90°$). (b) Elevation-1 ($\varphi = 0°$). (c) Elevation-2 ($\varphi = 90°$).

4. CONCLUSION

In this paper, a broadband bowtie antenna using a microstrip to CPS transition is proposed. The bowtie element and the transition balun are optimized for the frequency range from 2.2 GHz to 6 GHz. To verify the practicality of this antenna, we fabricated the antenna and measured the antenna performance. Both the measured and simulation results for return loss are in good agreement. The results of gain and radiation pattern also show good performances. Therefore, the proposed broadband antenna is very useful in various wireless application areas due to small size and simple structure.

ACKNOWLEDGMENT

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