Array of Quasi Rhomboid Shaped Element Bowtie Antenna with Reflector for Ultra Wideband Applications

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1. Introduction

The demands for broadband services by wireless communication systems are rapidly growing. An ultra wideband radio technology has become an important topic for microwave communication because of its low cost and low power consumption. The ultra wideband technology is specified the frequencies ranging from 3.1 GHz to 10.6 GHz by Federal Communication Commission (FCC), which has a bandwidth ratio (defined as higher frequency versus lower frequency) of approximately 3.3:1 [1]. The essential equipment for their wireless communication systems are the antenna that it is used for transmitting and receiving a signal. There are many types of antenna to choose for applying in the appropriate function and system. But one the major requirement of an ultra wideband application is a compact and extremely wideband antenna covering the ultra wideband spectrum. Microstrip patch antennas are well candidates for ultra wideband applications due to their exhibit small size, light weight, low manufacturing cost and easy method of fabrication. However, microstrip antennas have very narrow bandwidth. Therefore, the ultra wideband antenna design is going to the main challenges for ultra wideband system. The goal of the ultra wide band antenna designer is to make an antenna with small size, simple structure that produces low distortions but can provide large bandwidth.

Recent ultra wideband antenna development tends to focus on small planar antennas such as bow-tie antennas [2] elliptical antennas [3], slot antennas and array antennas [4]. Most of the reported all these antennas have omni-directional radiation patterns and the gain of these antennas are relatively low, about 2-4 dB. When these omni-directional antennas are attached to wall or metals, it is suspected that the antenna performances can be degraded due to the omni-directionality. In order to avoid degradation of the antenna performance, we considered placing a flat reflector behind the quasi rhomboid shaped bowtie antenna. In addition, if the directivity of the ultra wideband antenna increases as a result of the reflector, higher speed and lower power consumption communication system can be realized.

In this paper, we propose array of quasi rhomboid shaped element bowtie antenna design by using a flat reflector for ultra wideband communication systems. The proposed antenna consists of two elements quasi rhomboid shaped and aluminium flat reflector. This antenna is designed on FR-4 substrate and antenna analysis was conducted by using the IE3D program. The proposed antenna is realized and experimentally examined, since it is small size, light weight, easy method fabrication and low manufacturing cost. In measurement, it is found that the propose antenna have impedance bandwidth of 122.22% (2:1 VSWR) which covered frequency range 2.8-11.6 GHz. This antenna has uni-directional radiation patterns over the frequency range of 3.1-10.6 GHz for ultra wideband technology. For comparison purposes antenna, the average gain of the quasi rhomboid shaped bowtie antenna with and without the reflector, which average gain achieved in the quasi rhomboid shaped bowtie antenna using a flat reflector is much greater than without the reflector about 2 dB. The advantage of the proposed antenna is that it can be used to design impulse receive transmit system for ultra wideband applications.

2. Antenna Design and Fabrication

2.1 Single Element Bowtie Antenna without the Reflector

The simulation result by IE3D program, include impedance matching antenna length $\lambda/4$ of center frequency at 6.85 GHz. The antenna dimensional parameters after adjustments are w = 36.5, w_1 = 1.95, w_2 = 2.9, w_3 = 2.5, w_4 = 1.5, w_5 = 4.85, w_6 = 11.67, l = 10.5, l_1 = 30, l_2 = 11.75, l_3 = 3.65, l_4 = 2, l_5 = 1.1, l_6 = 7.85, unit in millimeter, $\theta_1 = 45^\circ$ and $\theta_2 = 116^\circ$. This antenna consists of two identical printed patches, one on the top and one on the bottom of the substrate material. The detailed geometry and parameters of the proposed antenna are illustrated in Fig. 1.

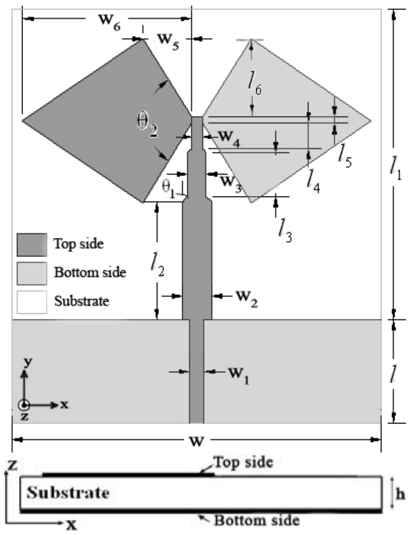


Figure 1: Structure and parameter of a single element antenna

2.2 Array Bowtie Antenna Geometry with the Reflector

The two elements array antenna using a flat reflector is modified from a single element. The substrate size is identical with the quasi rhomboid shaped bowtie antenna without reflector. The reflector shape is rectangle and the parameter d is the distance between the reflector and the dielectric substrate. The proposed antenna dimensional parameters after adjustments are 120.25×85 mm for aluminium ground plane and 5.78 mm above $\lambda/4$ in-thick aluminium ground plane. The feeding lines start from SMA connector with the width of 2.8 mm that corresponding to $50\,\Omega$. Next, it is split into 2 branches with impedance of $100\,\Omega$, transform with an impedance matching of $70.75\,\Omega$ and length of 10 mm, or $\lambda/4$ of the center frequency. Photograph of the array antenna prototype and size comparison with a metric ruler are illustrated in Fig. 2.

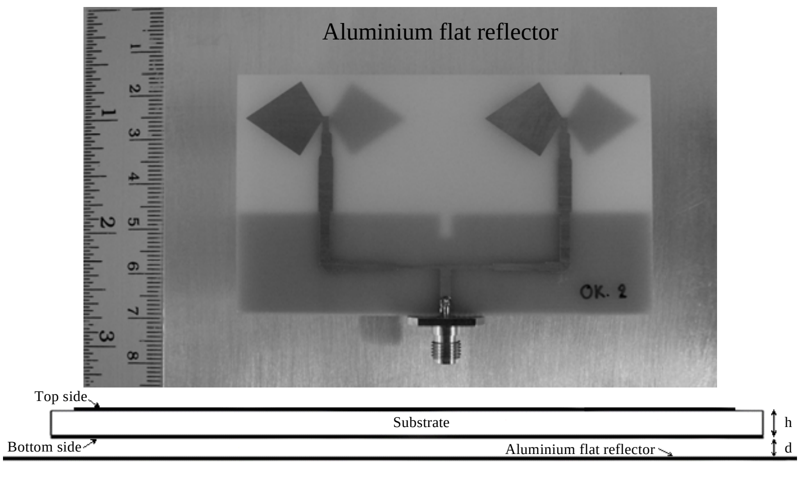


Figure 2: Fabricated prototype of two element array antenna using a flat reflector

3. Measurement and Results

3.1 Return Loss

Fig. 3 Plots both single element and two elements array antenna for input return loss. The return loss of the proposed antennas is measured by using a HP 8722D vector network analyzer. The measured return loss has a bandwidth (VSWR < 2:1) of 120.55%, 122.22% covered frequency range of 2.85-11.5 GHz, 2.8-11.6 GHz for single element and two elements array antennas, respectively. This shown that the bandwidth achieved in two element array antennas using a flat reflector is much greater than the single element about 2%.

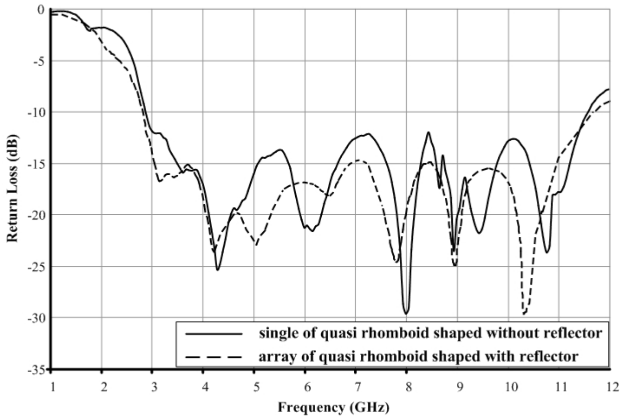


Figure 3: The measured return loss for a single and two elements array antenna using a flat reflector

3.2 Gain

Fig. 4 shows the gain of the both antennas is measured by using vector network analyzer. From this figure, reasonable average gain level is about 4 dB and 6 dB for a single element and two elements array antenna by using a flat reflector, respectively. The antenna gain in single element is not same two elements due to affected from number of antenna and flat reflector. In measurement, it found that a single element antenna has average gain less than the two elements antenna about 2 dB.

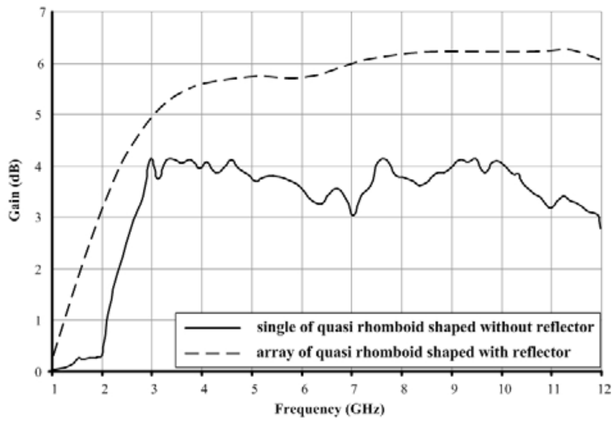
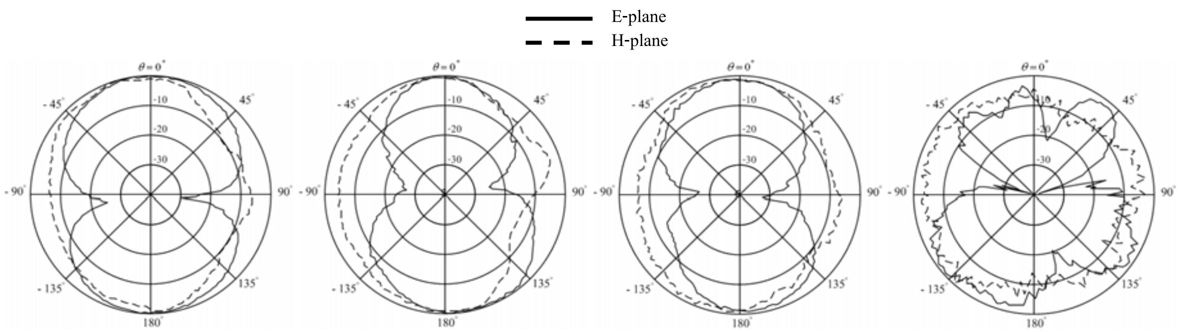


Figure 4: The measured gain for a single and two elements array antenna using a flat reflector

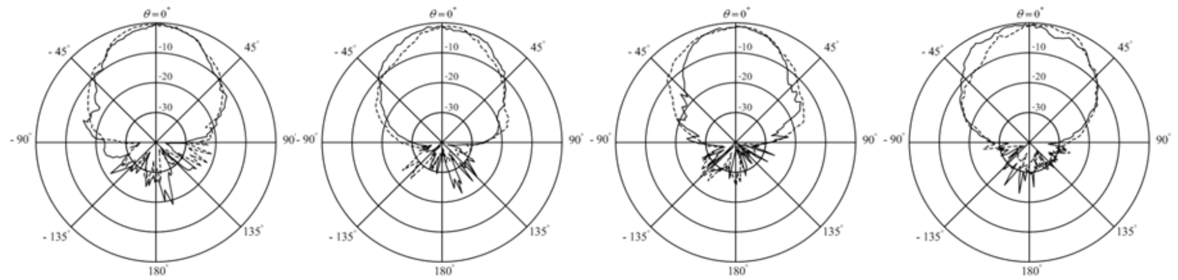
3.3 Radiation Patterns

The far-field radiation patterns were measured in an anechoic chamber. The antenna patterns are measured at selective frequencies that cover the entire operating band, and the results are presented in Fig. 5 a) and b) in the E-plane and H-plane at frequency 3.1, 5.1, 7.1 and 9.1 GHz. When is received at 45 cm, 65 cm from the transmitting antenna for a single element and an array structure, respectively. The proposed antennas are their stable radiation patterns. It can be seen that the quasi rhomboid shaped without reflector is satisfactorily omni-directional patterns in azimuth plane and the quasi rhomboid shaped two elements with reflector have uni-directional patterns. Referring to the Fig. 5 the measured E and H planes cross-polarization is not show because it is very low.



3.1 GHz 5.1 GH 7.1 GHz 9.1 GH

a)



3.1 GHz 5.1 GH 7.1 GHz 9.1 GH

b)

Figure 5: The measured E and H plane radiation patterns for a quasi rhomboid shaped at 3.1, 5.1, 7.1 and 9.1 GHz, a) single element without reflector b) two elements by using a flat reflector

4. Conclusion

In this paper, an array of quasi rhomboid shaped element bowtie antenna design by using a flat reflector is presented. The proposed antenna provides a wide impedance bandwidth covered frequency range 2.8-11.6 GHz. The proposed antenna has a measured return loss less than -10 dB over the operating frequency for ultra wideband applications. This antenna pattern has uni-directional radiation patterns at the considered frequency band. The quasi rhomboid shaped array antenna with reflector has average gain more than the quasi rhomboid shaped without reflector about 2 dB. The proposed antenna is fabricated on FR-4 substrate, since it is small size, easy construction and very low cost. For lead to use benefit in designed receive-transmit system of ultra-wideband technology.

Acknowledgments

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