A novel compact wideband tightly coupled bowtie antenna

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***Abstract*—A wideband Tightly Coupled Dipole Array (TCDA) is presented in this letter, which consists of a printed bowtie element, a wideband slot balun feeding network, a multi-section microstrip feedline and a wide angle impendence matching layer(WAIM). This type of antenna utilizes the coupling between unit antennas to achieve a wide bandwidth. The bowtie element and the balun are printed on a vertical printed circuit board. The unit cell is $0.5\lambda_{high}\times0.5\lambda_{high}$ (λ_{high} is the free wavelength at the highest end of the frequency band) . Simulated results show that the antenna can achieve a 3.8:1 bandwidth with VSWR≤ 3 at broadside and achieve a 4:1 bandwidth within ±45° scanning range in E and H planes with VSWR ≤ 3.**

Keywords—Tightly coupled dipole antenna;wideband; mutual coupling.

I. Introduction

Ultra-wideband phased array antennas are generally used in multi-functional radars, wideband or ultra-wideband radars, electronic countermeasures and opposition, communications and other fields, so it is worthwhile to study it. However, there are many challenges to design this type of antenna. In light of this situation, Many domestic and foreign scholars have proposed some ways to broaden the bandwidth of antenna.

In general, the traditional technologies can be divided into two types. The first is such as Spiral antenna, bowtie antenna, monopole antenna etc, but they are limited by the application platform. The second is the Vivaldi antenna[1]. It can get a 10:1 bandwidth. However, the profile of the Vivaldi antenna is too high. Moreover, The impedance bandwidth is affected by the mutual coupling of the element and it is difficult to expand the bandwidth.

In recent years, the tightly coupled array (TCA) has been widely used in the ultra-wideband antennas. The novel array antenna is based on the concept of a Wheeler-based current sheet [2]. Differently from the traditional array, the TCA increases coupling by a closer distance between nearby elements, which can realize a wide bandwidth. Compared with conventional phased arrays, tightly coupled antennas have the advantage of small size, wide bandwidth and wide scanning angle etc[3]–[5].

In general, there are two difficulties in designing tightly coupled antennas. The first is the design of balun. Balun not only requires miniaturization but also impedance matching. In addition to the integrated baluns [6], another balun proposed in [7] also provided a novel feeding structure for wideband phased arrays. The second is that When the antenna is scanning, the impedance will be mismatched. In view of this situation, a special dielectric layer palaced above the antenna can solve this problem. In [8], the TCDA composed of horizontal inter-digital electric dipoles and two WAIM layers is developed. The bandwidth is optimized to more than 5.7:1, with VSWR ≤ 3 while the scanning angle ranges up to ±55° in E-plane and ±50° in H-plane. In [9], a novel parasitic superstrate was put forward The proposed design achieves 6.1:1 bandwidth, with VSWR < 3.2 while scanning to ±60° in H-plane and ±75° in E-plane.

In this paper, we focus on the simplification of the antenna. The dipole unit and the integrated balun is designed. A WAIM layer over the antenna is used to achieve broadband and wide-angle scanning. The antenna achieved performance of 3.8:1 bandwidth with VSWR less than 3 at broadside. when scanning to ±45° in E-plane and H plane, it can achieve 4:1 bandwidth with VSWR≤ 3.

II. Antenna Configuration

The geometry of the proposed TCDA is shown in Figure 1. It is printed on the substrate with the dielectric constants of 2.55, the height of 0.8mm. The proposed antenna is composed of four parts, including the bowtie element, the multi-microstrip feedline, the slot balun and the WAIM. The dipole and the microstrip feedline are printed on the top surface of the substrate and the slot balun is printed on the bottom surface of the substrate. The optimized antenna dimensions are listed in Table I.

A metal is placed on the bottom surface of the substrate to produce coupling capacitor. In this way, the self inductance of the antenna unit and the introduced coupling capacitance will offset the reactance introduced by the ground and widen the bandwidth of the antenna. Meanwhile, a traditional dielectric layer which has the dielectric constants of 2, the height of 1mm is palaced above the antenna .

As is shown, the antenna is simply comprised of dipoles

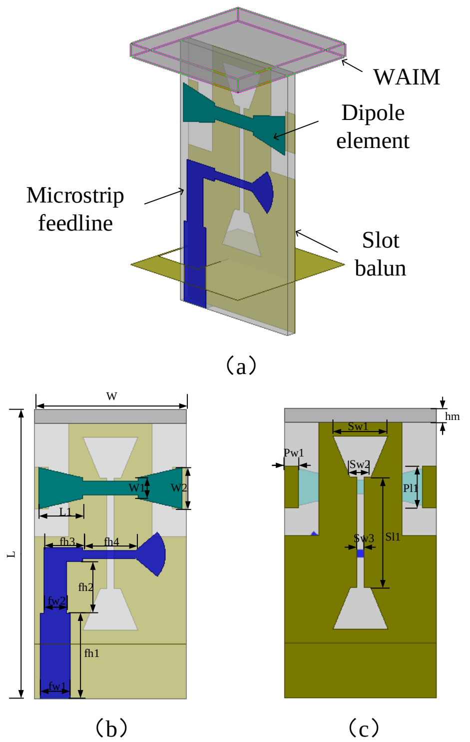

Fig. 1 Configuration of the proposed antenna. (a) 3-D view. (b) Top view. (c) Bottom view

TABLE I ANTENNA DIMENSIONS

Parameter	Value	Parameter	Value
W	11mm	fh1	6.2mm
L	20mm	fh2	4.8mm
L1	3.2mm	fh3	2mm
W1	1.5mm	fh4	4mm
W2	3mm	fh5	4mm
fw1	2.2mm	Sw1	4mm
fw2	1.6mm	Sw2	1.5mm
hm	1mm	Sw3	0.5mm
Pw1	1mm	Sl3	8mm
Pl1	3mm		

and balun, no extra power dividers are involved. This will notreduce unnecessary power loss. The slot balun achieves theunbalanced-to-balanced transformer from the microstrip feedline to the dipole antenna. In order to obtain the unbalance-to-balance transformer from the microstrip feedline to the dipole antenna. the bottom side of the substrate, and installed to be vertical to the dipole and microstrip feedline. The feedline is firstly coupled to the slot, and then coupled to the dipole from the slot. The current coupled to the two arms of the dipole are of equal magnitude and 180° out-of phase, and unbalance-to balance transformer between the microstrip feed-line and the dipole antenna is obtained. Several impedance transformations occur through the coupling path from the microstrip feed to the dipole.

III. SIMULATION AND MEASUREMENT RESULTS

The antenna element is simulated in an infinite array environment. Fig. 2 shows the simulated VSWR of an unit cell in an infinite array. It is observed that the bandwidth is 3.23-12.41GHz when VSWR <3 at broadside. When scanning in E-plane, the bandwidth of unit improves to 4:1. We note that in the H-plane scanning the bandwidth also exceeds 4:1 .

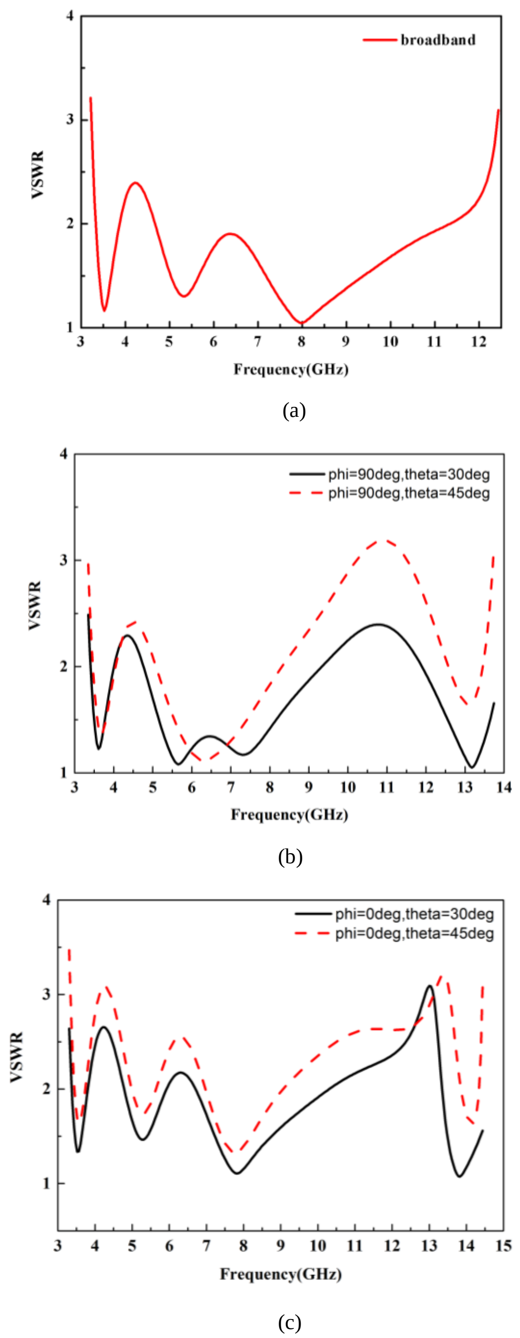

Fig. 2 The simulated VSWR of an unit cell in an infinite array (a)broadside (b) E plane scanning (c) H plane scanning

IV. CONCLUSION

A novel bowtie antenna with integrated slot balun has been proposed. The working principle of slot balun has been analyzed. The measured results show that the proposed antenna possesses an impedance matching bandwidth of 3.8:1 bandwidth with VSWR≤ 3 at broadside and achieve a 4:1 bandwidth within ±45° scanning range in E and H planes with VSW ≤ 3.

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