A 3.37:1 Bandwidth and Low-profile Tightly Coupled Array Antenna

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Abstract **– A low-profile, broadband array antenna based on tightly coupled dipole array is presented. The array antenna does not need any external matching structure and equipment. The simulation results of the infinite proposed array show 3.37:1 bandwidth (1.97 GHz to 6.66 GHz) with VSWR < 2 at broadside radiation and above 95% radiation efficiency over the operating frequency band. The height of the array including superstrate is 1/12.7 λ at the lowest frequency band.**

Index Terms **— Array antennas, broadband antennas, phased arrays.**

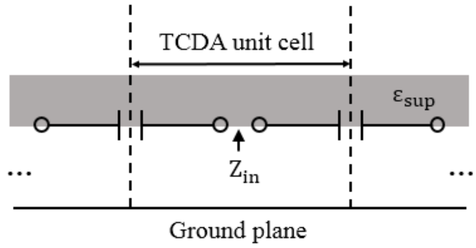
1. Introduction

Wide bandwidth and low profile antenna is required to recent generation communication devices and multi-functional radar. Tapered slot antenna (TSA) or Vivaldi antenna is the conventional antenna for ultrawideband array [1]. However, the antennas have limitations of high profile, high cross polarization, and narrow scanning angle. Connected dipole arrays based on Wheeler's current sheet array (CSA) are proposed [2], and it shows the infinite bandwidth when the array antenna located in the free space [3]. Though, when the antenna is located on the ground plane, a resonance arises at the low frequency, thus the antenna have the reduced bandwidth related on the distance between antenna and ground plane [4]. Munk proposed tightly coupled dipole array (TCDA) and its equivalent circuit [5]. The principle of broad bandwidth of the TCDA is that the coupled capacitance of neighboring dipole elements cancels out the inductance of the ground plane at the low frequency, thus the array has characteristics of related low-profile and wideband. After the TCDA concept is devised, implementation of TCDA is presented [6], [7].

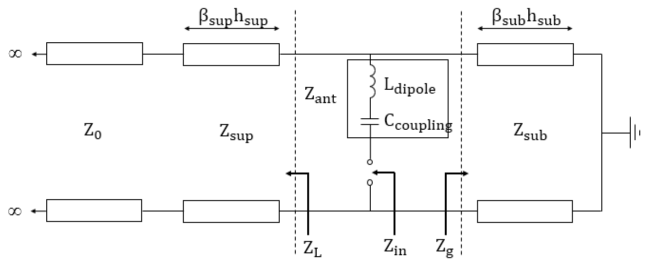
In this paper, we proposed the unit cell of the tightly coupled array antenna focused on low-profile. The proposed array has shorting posts and via holes to control the undesired resonances in the operating band, and shows broadband, high radiation efficiency, and high polarization purity.

2. TCDA concept and equivalent circuit

As mentioned, Munk invented the TCDA concept and unit cell of its equivalent circuit as shown in Fig. 1. The inductance of the dipole corresponds to L_{dipole}, and coupled capacitance between neighboring dipole elements corresponds to $C_{Coupling}$. From the point of dipole's view, the impedance looking into ground seems like short-circuited transmission line, which characteristic impedance is Z_{sub}. The impedance of opposite direction seems like Z_0-terminated transmission line, which characteristic impedance is Z_{sup}. The impedance bandwidth of TCDA is determined when the input impedance $Z_{in} = Z_g // Z_L + Z_{ant} \approx 50\ \Omega$.



(a)



(b)

Fig. 1. (a) Tightly coupled dipole array concept schematic. (b) Equivalent circuit of TCDA.

3. Proposed low-profile, broadband TCA

The proposed TCA unit cell is shown in Fig. 2. The unit cell spacing is 18 mm × 18 mm, and the overall height is 12.1 mm. The vertical gap behaves as capacitance that is added to $C_{coupling}$ in series to lower the total capacitance. Consequently, the Z_{in} of TCDA with vertical gap is more suitable to achieve low-profile characteristic. The shorting posts is used to control the common mode resonance, and the via holes are used to remove the undesired internal resonance in the operating band. The shorting posts and via holes are not only control the undesired resonances, but also influence the impedance matching.

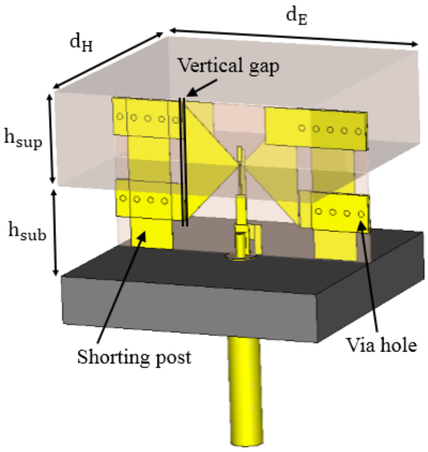


Fig. 2. Unit cell of proposed array.

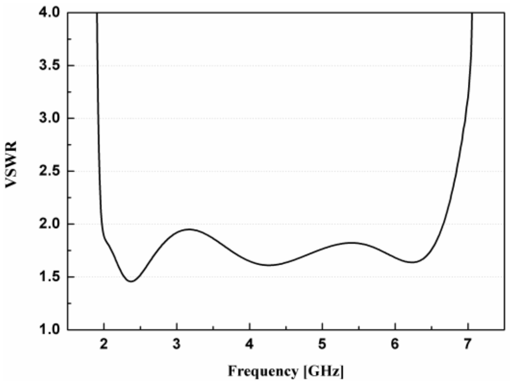


Fig. 3. VSWR of proposed TCA.

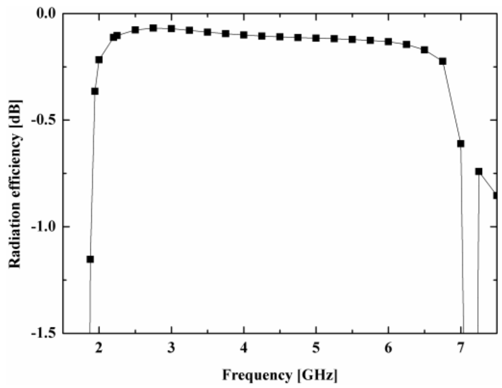


Fig. 4. Radiation efficiency of proposed TCA.

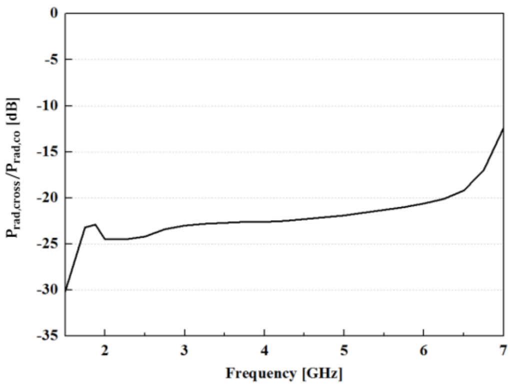


Fig. 5. Ratio of cross- to co-polarization radiated power from infinite unit cell of proposed array.

The VSWR of the proposed array antenna is shown in Fig. 3. As shown in Fig. 3, when the infinite × infinite array, the impedance bandwidth is 3.37:1. The radiation efficiency is presented in Fig. 4. The radiation loss is lower than 0.4 dB over the operation frequency band. In Fig. 5, the ratio of cross-polarization to co-polarization radiated power, according to the Ludwig's 3rd definition, is presented. With regard to the polarization ratio, the cross-polarization power is less -20 dB than co-polarization power. Thus the majority radiating power is co-polarized.

4. Conclusion

We proposed low-profile, broadband TCA antenna which consists of ground plane, vertically standing dipole array with vertical gap, and the superstrate. The height of the proposed array is 1/12.7 λ, and external feeding structure is not necessary. The impedance bandwidth is 3.37:1 with low radiation loss < 0.4dB and low cross polarized radiating power.

Acknowledgment

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